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MOBILITY OF MAN-POWER IN BRITAIN

THE broadsheet "Man-power Movements" (No. 276), which Political and Economic Planning issued in January, develops further a theme on which an earlier broadsheet, "Framework of Collective Bargaining" (No. 272), published in October, had touched slightly; a theme the importance of which has been accentuated by the growing seriousness of the economic situation of Great Britain. The existence of that crisis was not clearly recognized when the "Economic Survey for 1947" (Cmd. 7046) was issued, and even now the imminent risk of a further and still more serious reduction in our standard of living is not widely appreciated. Too little is still known, as this new broadsheet reminds us, about productivity; it is recognized that redistribution of man-power is essential in order to realize the projected investment and consumption programmes, but the point is clearly made that man-power movements alone are insufficient. Economic planning is equally a matter of management, machines, materials, money and, as the broadsheet says pointedly, ministries; and the value of man-power policy depends on its appropriateness in relation to other policies and to their general aim, which must contribute towards keeping the economy in balance.

What should be remembered in considering the Control of Engagement Order, 1947, is that no steps were taken in 1945–46, comparable with the measures adopted in war-time, to see that workers went where they were most likely to be needed. Serious political difficulties would have been involved in any attempt to guide more positively the flow of labour from the Armed Forces and from war industries. Various measures of control were, however, retained for a time over the movements of coal-miners, agricultural, building and textile workers, nurses and Civil servants. The real gravamen of the criticism of the policy then adopted is that the public was not made to realize that wider measures of control might be necessary, and nothing positive was done to correct the dangerous tendencies. The smoothness of demobilization was, indeed, partly due to the fact that workers were going where they wanted to go, irrespective of where they might be most needed; and even the Economic Survey for 1947, in noting the shortage of workers in coal-mining, textiles and agriculture, did not face the fact that transfer from, or restraint of expansion in, other industries might be necessary.

The *Planning* broadsheet maintains that neither the premature exhaustion of the United States loan nor the further deterioration in the terms of trade altered the situation so drastically between February and September 1947 that planning could not last year have been visualized as a problem of securing the acceptance of uncomfortable measures necessary to realize the plans. The main problems of man-power were recognizable two years ago, and very slow progress has been made towards solving them. The present requirements are, first to effect an immediate improvement in the 'bottle-neck' in-

dustries; next to expand production (as distinct from productivity) in industries devoted to exports, import substitutes and certain consumer goods; thirdly, to increase the output per man-hour so far as the concentration of investment on the second permits, and where necessary to increase hours of work; and last, to restrict production in those industries which compete for labour and raw materials with the industries already indicated.

In regard to the first, P.E.P. considers that it is doubtful whether enough has yet been done to solve the problems of 'bottle-neck' industries through a more efficient use of their products. There are two other methods of adjusting deficiencies in such industries without inter-industrial movements of man-power. Output per man hour could be increased by better organisation of production by managements, the use of more or better machinery or by a voluntary increase in effort due to improved worker – management relations, national appeals or material incentives—improved quality of the products could also help—but if these methods fail, the working of longer hours may be necessary as a last resort.

Dealing then with the size of the problem, the broadsheet maintains that the whole concept of an absolute, general shortage of labour is dangerous and misleading, tending to distract attention from the fact that the targets are too high and from the need to increase productivity. Furthermore, it points out that difficulties arise not from the fact that large numbers are required, but from the unattractiveness of the jobs, and from such problems as housing in areas where industries urgently need workers. It raises the question whether the Control of Engagement Order should ever have been imposed, even if it were certain that it would solve the immediate problem. Political and Economic Planning maintains that the present problem is exceptional only in degree, not in its nature, and that the maintenance of 'full employment' will always necessitate measures to combat the rigidity of labour distribution. Finally, it attributes the distortion of the labour structure from the pattern dictated by present needs primarily to the fact that for many years Great Britain has been enjoying a substantial proportion of free imports.

Nothing less than the whole future of 'full employment' in Britain is at stake. The broadsheet directs attention to the importance of the workers having complete confidence in the security of employment if mobility is to be secured; and it makes its most important point in insisting here that it is necessary to convince workers also that a degree of mobility between industries is permanently needed if full employment is not to prejudice the efficiency and adaptability of the economy. A fresh approach should be made by the whole Government public relations service, with which the National Joint Advisory Council should co-operate to the full. Labour controls cannot provide the answer to the long-term problem of distributing labour, and some method must be found which will be flexible. efficient, secure, and retain the confidence of both employers and workers, and make use of the natural motives and incentives normally influencing the individual. Our lack of knowledge about these motives and incentives makes the need for research and experiment only the more urgent.

One field for research suggested in the broadsheet is a study of the high degree of mobility which appears to exist among the professional and managerial classes; such a study might yield valuable information for the basis of an incentives policy, which is as essential as some sort of wages policy. Again, the need for research into the statistical, geographical, industrial, social and psychological factors affecting labour distribution and mobility is urgent. The results of the research should be given the widest publicity. There may well be great scope in this field for the British Institute of Management, though official initiative is also important; *Planning* welcomes the recent establishment of a Scientific Committee on Industrial Productivity. One of the most urgent needs is for an inquiry to supply the data on the occupational distribution of the population which would have been provided by the Population Census of 1941. The public needs the fullest possible basis of knowledge to enable judgments to be made on the man-power problems of full employment, and no one concerned to see public policy guided by knowledge and reason rather than prejudice should fail to support P.E.P. in its contention or to press on the Ministry of Labour the opportunity it has there, since the control and co-ordination of the strategy of man-power planning must be centralized in its hands.

The account of collective bargaining which P.E.P. offers in its broadsheet on this subject (No. 272) as a contribution to public understanding is valuable, and forms one of a series of studies in British trade unionism being published. It is primarily factual and descriptive, and brings up to date material contained in the Industrial Relations Handbook published in 1944 by the Ministry of Labour; but it also covers certain subjects, such as wages councils, which are not included in that Handbook. It thus helps to fill the need for a comparatively simple guide to the main varieties of collective agreement and the way in which they have developed.

The broadsheet shows that nearly 90 per cent of the insured workers of Great Britain are covered by negotiating machinery of one kind or another, and of these about one third are in six great key industries, all of which have developed their own characteristic machinery on a voluntary basis. Another third are in industries covered by the Whitley system of national joint industrial councils. The admirable description of this system is the feature of the broadsheet of most interest to the scientific worker; although there is no discussion of the problems arising out of the association of the professional worker or manager with such bodies. The remaining third are covered by statutory wage-fixing machinery; this section of the broadsheet deals with the Wages Council Act of 1945, which renamed and reorganised the old Trade Boards.

Both broadsheets 272 and 276 emphasize the point made in an earlier broadsheet on "The Plan and the

Public", and which Sir Oliver Franks brought out so well in concluding his Sydney Ball Lecture, "The Experience of a University Teacher in the Civil Service", regarding the vital importance of public relations work in securing effective co-operation. Unless the generalities in which Government economic policy is contained can be effectively interpreted and communicated to those required to help in carrying out the policy, methods of reason may break down. The chief responsibility for setting policies before the public must rest with Ministers. But some responsibility must also rest upon Civil servants in their many dealings with the public, and on management. It will often depend on how they expound and administer a policy whether the conception of something 'we' are committed to carry through replaces that of something 'they' have ordained.

ORIGINS OF SPECIES AND MIGRATIONS OF FLORAS

The Genus Crepis

By Ernest Brown Babcock. (University of California Publications in Botany, Vols. 21 and 22.) Part 1: The Taxonomy, Phylogeny, Distribution and Evolution of Crepis. Pp. xii + 198. 3.50 dollars. Part 2: Systematic Treatment. Pp. x + 199–1030 (36 plates). 10 dollars. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1947.)

THE appearance of Babcock's monograph after four years delay in the press, due doubtless to the War, is an event of considerable importance, not only to botany but also to the biological sciences in the widest sense. Familiar as are parts of it to specialists, through the publication of numerous papers during a period of over twenty-five years, the collation of all this work in monographic form should bring it into the hands of a far wider circle of readers.

Part 2, the larger portion, resembles at first sight a systematic monograph of the ordinary type. It contains the morphological background to the cytogenetic work obtained by the use of all the ordinary criteria available to taxonomy; for example, comparison of herbarium specimens, collation of literature, etc., illustrated by outline drawings to a uniform scale of almost all the 185 species which are described. It contains, however, far more than this. For the first time, in a work of this magnitude, cytogenetic information on a scale unknown in any other group of plants or animals, not even excepting *Drosophila*, is included. It is true that from the point of view of pure genetics individual species such as *D. melanogaster* or *Zea Mays* far exceed anything which has yet been attempted in *Crepis*. We have here, on the other hand, a cytological record, in many cases amplified by genetical information derived from inter- and intra-specific crosses, of no less than 113 species of a monophyletic genus which spreads from Eurasia to Africa and America, a genus, moreover, which is exceptional among plants for the low number and large size of its chromosomes. Full credit is given in the introductory paragraph to Part 1 to the early work of Rosenberg, Juel and Digby, who first detected $n = 3$ in *Crepis capillaris* and $n = 4$ in *C. tectorum*. To Babcock is due, however, the credit of recognizing the importance of low chromosome number in 1915, and for having stimulated by his exertions not only a numerous school of collaborators in the United States, but also some outstanding cytological workers in the Old World, notably the Russian school under Nawaschin. The result is a display of cytological information which has never previously been equalled and which will long remain unsurpassed. The incorporation of this knowledge in the systematic monograph places it at once in a class apart.

Scarcely less important are the geographical data included in the numerous distribution maps appended to the various sections of the genus. Until quite recently information about the floras of large tracts of country, notably in central and north-eastern Asia, was so meagre as to preclude an effective treatment of the plant geographical development of the floras of the northern hemisphere considered as a whole, with the result that an over-emphasis on Europe led to very widespread misconceptions on the order and importance of events which are only now becoming apparent. Recent phyto-geographical exploration of these missing regions, notably by Hultén[1], is profoundly altering previous concepts, and it so happens that north-eastern Asia turns out also to be of fundamental importance in the evolution of *Crepis*. The collation of the geographical evidence on plant migrations with the cytogenetic evidence on the order of evolution of species is not the least important part of the whole work. The detailed discussion of endemism in this context, enriched with the certain knowledge as to which endemics are relics and which innovations, knowledge which is impossible without the type of cytogenetic and morphological data here assembled, also enables the author to discuss not merely plant migrations and the origin of the floras of four continents, but also cognate matters such as the theory of 'age and area', with effectiveness and, in part at least, with the semblance of finality.

These matters are dealt with in Part 1 of the work under review, and their close perusal is much to be recommended to geographers, zoologists and botanists interested in other groups inhabiting these regions. Part 1 also contains, among other things, the summary of the main cytogenetic conclusions on the mechanism of evolution in *Crepis*, a statement which may profitably be amplified for the general reader by perusal of a still more recent summary by Babcock in another connexion[2]. From the analysis of 113 species and very numerous interspecific hybrids, *Crepis* is seen to be a genus which, on the whole, has evolved with little aid from polyploidy and by a process of reduction rather than increase in chromosome numbers. Polyploidy has affected less than 8 per cent of species. Interspecific hybridization has been involved in some 20 per cent of species, and primary importance has to be assigned to the internal action of segmental interchange and genic mutations, aided by genetic, geographic or ecological isolation, in making possible the morphological and physiological differentiation of the rest. Detailed information is provided about the mode of operation of both the latter processes in the speciation of various parts of the genus, and the importance of work such as that of Tobgy[3] and Gerassimowa[4] in revealing how segmental interchange can alter chromosome morphology and set up sterility barriers without other genetic changes is very clearly brought out, especially in Babcock's later article[5], and in doing so a very important gap in our knowledge of evolutionary mechanisms is partially filled, with fact instead of surmise.

Finally a survey is given of the numerous outstanding lines of work which could be further pursued with profit. It is to be hoped that this work will indeed be continued, and this seems the more probable in that it has already been supported for more than a quarter of a century by a State (California) Agricultural Research Station, although *Crepis* is a genus of no economic importance. It is fitting to express appreciation of such an enlightened policy, and the world is no less indebted to the University of California for providing in its "Publications in Botany" a medium admirably suited in format and style to the issue not only of individual research papers of the usual kind, but also to an extended work of pure scholarship of the dimension of a large book such as that under review. International co-operation and disinterested support of fundamental research on this scale cannot easily be found even to-day in this age of planned science, and this is perhaps not the least important of the issues raised by Babcock's work. I. MANTON

[1] Hultén, E., "Outline of the History of Boreal Biota during the Quaternary Period" (Stockholm, 1937).
[2] Babcock, E. B., *Advances in Genetics*, **1**, 69 (1947).
[3] Tobgy, H. A., *J. Genet.*, **45**, 67 (1943).
[4] Gerassimowa, H., *C.R. Acad. Sci. U.R.S.S.*, **11**, 143 (1937); **25**, 148 (1939).

RADIOELEMENTS AS A TOOL IN SCIENTIFIC RESEARCH

Radioactive Tracers in Biology

An Introduction to Tracer Methodology. By Prof. Martin D. Kamen. (Organic and Biological Chemistry, a Series of Monographs, Vol. 1.) Pp. xiii+281. (New York: Academic Press, Inc.; London: H. K. Lewis and Co., Ltd., 1947.) 5.80 dollars.

AT the beginning of this century, one of the facts most intriguing to chemists was the impossibility of concentrating some of the radioactive elements. Radium D, for example, a substance well characterized by its radioactive properties, proved to be completely inseparable from the large quantities of lead with which it was always burdened when extracted from minerals. Early in 1913 it was realized that the strange inseparability observed in radiochemistry, and the atomistic complexity of inactive elements as revealed by mass spectroscopy, were aspects of one and the same phenomenon, for which the new Rutherford–Bohr theory of the atom provided a convincing explanation. But even before this recognition of the nature and importance of 'isotopy', attempts had been made to turn the negative results of the separation experiments into a positive service to science: the solubility of sparingly soluble lead salts was determined by mixing them with radium D and using the imparted radioactivity for the electroscopic measurement of the invisibly small quantities of dissolved lead.

In those days there were only half a dozen or so suitable radioelements available, all of them in the last two rows of the Periodic Table. Therefore, 'radioelements as indicators', while a great help for a variety of investigations in inorganic and physical chemistry, were scarcely applicable to biological experiments—although so early as 1923 G. von Hevesy made some interesting observations about the intake of lead by plants by means of such an indicator. For the most important biological elements like carbon, hydrogen, oxygen, phosphorus, sulphur, or sodium, unfortunately no radioactive isotopes were known. Now the 'labelling' of an element should be possible also with inactive isotopes, though the methods of their detection and measurement are necessarily different and, in general, less simple; but in those days this way was barred too, as no means were known of preparing the inactive isotopes in more concentrated form than they occur in Nature, let alone in a pure state.

To-day in both directions the situation has completely changed. The discovery of the artificial radioelements in 1933 soon made radioactive isotopes of most of the elements available, and the development of several methods for isotope separation also put inactive atomic species at the disposal of scientific workers. As a consequence, the use of 'tracers', as they are now usually called, became a much more important practice in biological as well as non-biological research. Of special influence in this development was the erection during the War of big plants in the United States for isotope separation and for plutonium manufacture, the products and by-products of which can now be used for peaceful purposes. Similar plants will soon be operating in Great Britain and Canada; but in the meantime the American Government is willing to provide scientific workers all over the world with the invaluable materials, under the same conditions as laid down for American laboratories.

In these circumstances, many scientific workers who have otherwise no contact with radioactivity are anxious to make themselves acquainted with the powerful new method. By far the best way is, naturally, a course of instruction in one of the radioactivity centres; but as the principles of the method are simple, and the apparatus as well as the tracer material can be bought, training by books is certainly possible. It is therefore a pleasure to find that an excellent guide to the tracer technique with radioelements has been published by one of the most successful workers in this field. Prof. M. D. Kamen calls his manual "Radioactive Tracers in Biology"; but he is so thorough in making the reader well acquainted with the physical and chemicals aspects of radioactivity and with the theory of the measuring instruments before discussing biological applications, that those who intend to use radioactive tracers for non-biological research will also find in the book a wealth of useful information. In points of detail there may be some disagreement. Thus the author defines 'specific activity' (p. 33) as the ratio of the number of radioactive isotope atoms to the total number of isotope atoms; while later (p. 152) he uses as specific activity the number of counts per minute per milligram. Most workers in this field will probably prefer the second definition; and they may also not share the author's predilection (p. 91) for the term 'rutherford' instead of 'curie' (compare, *Nature*, **160**, 778; 1947).

Biologists will find the final chapters of particular value, for here the author deals, one by one, with the principal radioactive tracers as applied to metabolic studies. Very frequently he can draw on personal experience, and his descriptions display all the freshness which only first-hand knowledge can impart. In conclusion, we would like to express the hope that the other branches of radioactive and inactive tracer methodology will soon find authors as competent and literarily gifted as Prof. Kamen has proved himself to be in the very important field he has chosen as his own. F. A. PANETH

ECOLOGICAL PROBLEMS OF THE HIGHLANDS AND HEBRIDES

Natural History in the Highlands and Islands
By Dr. F. Fraser Darling. (New Naturalist Series.) Pp. xv+303+64 plates. (London and Glasgow: Wm. Collins, Sons and Co., Ltd., 1947.) 16*s.* net.

THIS is a notable book about Scotland north and east of the Highland Border Fault, where much that is wonderful and unique in Nature still flourishes; its case for a new deal for the Highlands and Hebrides, because it is developed on detailed ecological considerations, and its humanism (without 'bogus romance'), also make it a different kind of book. The author, rightly esteemed for his biological researches in the region and for his present labours as director of the West Highland Survey, is almost certainly the one man possessing the qualifications to attempt it.

The first three chapters deal with geology, climate, relief and scenery, the other nine with human and animal factors: forest, moor and farm; hill summits; shore, sea, loch and shallow seas; islands; freshwaters; red deer; grey seal; and reflexions on main issues. There follow a long bibliography, index and fifteen distribution maps by Dr. James Fisher.

The book merits the compliment of searching criticism. The reviewer and biological colleagues agree that, much though they welcome its advent, a longer gestation and more consultation with specialists would have given it better proportion and minimized the number of blemishes. The citation of even typical slips and errors regarding altitudes, distribution, nomenclature, cross-references, etc., would occupy too much space here; such will be communicated to the author. Those using the book scientifically require, therefore, to be warned of the necessity for checking details by reference to authoritative sources.

Certain matters of printing craft cannot be so passed over. The plates, mostly, are original and very attractive; everything possible has been done with many of the coloured photographs, but it is disconcerting to see two colour plates (18 and 23, review copy) half an inch out of register. Regarding the black-and-white illustrations, perhaps the paper used is the best obtainable now; but it does not appear to be the most suitable, the plates often being flat and dense (for example, III, review copy). Another copy shows duplication of bibliography, one index page, and maps.

The sentiments and style of the fine concluding chapter deserve applause. The author speaks of his loved country "with its power, colour, variety and movement; the diversity of living forms and the delicacy of their inter-relations"; of its sufferings and despoliation following the two revolutions that struck it—the coming of the sheep after the destruction of the forests, and the delight in game preservation which practically meant the killing of common mammals and birds without reference to their life-history. "Let us," he says, "give beast and bird and flower the place to live *in its own right* unless pest or obnoxious parasite."

What is being done about it all? Promise of much lies in the concern expressed by those in high place (the Secretary of State for Scotland and others) for schemes of forestry, national parks, crofting and hydro-electricity. But progress would be speeded and intensified by the co-ordination of such schemes, by the education and "active work of ordinary folk, of people who visit the Highlands and of those who live there"; and, with all this good will, by the institution of "a trained wild-life service, a corps of men working on natural history, studying phenomena and forecasting consequences and gaining a knowledge of the dynamics of natural populations".

Despite its shortcomings of detail the book is a gallant effort, much needed, stimulating and highly successful. Its appreciation by the reviewer and a colleague (neither Scottish) is measurable by the fact that between them they bought a dozen copies as gifts to laymen and younger naturalists.

A. D. PEACOCK

POLITICAL TESTAMENT OF AN ANTHROPOLOGIST

Freedom and Civilization
By Bronislaw Malinowski. Pp. xiv+338. (London: George Allen and Unwin, Ltd., 1947.) 16*s.* net.

BRONISLAW MALINOWSKI died in the United States in 1942 leaving a number of unfinished manuscripts in various stages of development. Two of these, "A Scientific Theory of Culture" (reviewed in *Nature* of August 25, 1945) and the present work, to some extent overlap. "Freedom and Civilization" may be regarded as a war-time political manifesto superimposed on the body of anthropological theory expounded in the earlier volume. This topical quality is manifest in the introductory section, "Political Prelude", and in the first chapter of Part 2 entitled "What we are fighting for". It is therefore unfortunate that the book-wrapper of the present English edition should give the impression that the book is an 'objective' contribution to political philosophy.

Objectivity was never Malinowski's method. Like all great teachers, he was prone to generalize recklessly from a special instance in order to drive home a point of principle. Some of the categorical assertions of this book are startling and would be hard to justify by any 'objective' criterion; for example, "a regular, systematic or tyrannical abuse of authority is not to be found under primitive conditions" (p. 118), or "in primitive communities the magician . . . always inspires the community with a consciousness of discipline and with the faith in leadership" (p. 213), or again, "headhunters and cannibals cannot loot because there is no portable or accumulated wealth at that stage" (p. 281). But such statements seem to me to be not so much unverifiable assertions as decorations to the general argument.

This argument is the declaration of a political *credo*, a statement of liberal positivist faith in the human spirit which belongs to the tradition of J. S. Mill's treatise "On Liberty" or Condorcet's "Esquisse d'un tableau historique des progrès de l'esprit humain". The latter perhaps is a particularly appropriate parallel, for it was written in the war-time Paris of 1793, a few months before its author's death.

Approximately one third of the book is devoted to a critical examination of the concept of freedom, and to the selection of a range of meaning for this emotionally overloaded term which will satisfy the author's requirements. This long discussion of what is largely a problem of semantics could with advantage have been well pruned in final draft. The sequence of the argument thereafter appears to rest on the

following set of premises: (*a*) the concept of freedom can only be judged against a background of fundamental human needs which are served by the necessary restrictions on the individual imposed by human culture (pp. 89, 100); (*b*) the evolution of the practice of warfare since archaic times is manifested in the culturally defined behaviour of various grades of modern 'primitives' (Part 5, Chapter 5); (*c*) the Anglo-Saxon concept of democracy, as interpreted by Malinowski (p. 231), is a logical development from the ideology of "the earliest human cultures known to anthropology"; (*d*) the mutual interaction of institutions in a primitive 'tribe-nation' is normally such as to inhibit the development of civil war (pp. 262, 279); (*e*) totalitarian political organisation is an aberration from the normal because it has, as its inevitable concomitant, total war, which is a civil war within the body politic of world civilization (pp. 293, 309, 317).

To achieve this 'scientific proof' of the villainy of Hitlerism is something of a *tour de force*. In the context of 1942 it was perfectly justifiable; but it needs to be stressed that resort is had to some very question-begging definitions and assumptions. The important argument on pp. 252–255, which insists that 'a tribe' can be equated with 'a culture', and that such discrete units are always readily identifiable on the ground, strikes the present writer as highly questionable. Or again, the restriction of the meaning of 'war' to "an armed contest between two independent political units carried out by means of organised military force in the pursuit of a tribal or national policy" (p. 277) leads to the somewhat artificial inference that the aggressive activities of "the lowest primitives . . . headhunters and cannibals cannot be regarded as real war" (pp. 277, 281); moreover, by implication, they cannot be regarded as civil war either (pp. 281, 293). But by much the same argument a pedant might argue that the current unpleasantness in Greece and Kashmir is also neither real war nor civil war.

Another consequence of the political objective of the book is that the anthropological content is backed up by evolutionary doctrines which no longer find any place in ordinary anthropological academic discussion. As a teacher, Malinowski was always at pains to stress that the speculative reconstruction of long-term history could form no part of a scientific anthropology, and it is a shock to find him here discussing various groups of modern primitives in strictly parallelist evolutionary terms. But though the attempt to blend anthropological theory and political philosophy is not entirely successful, it raises wider issues. Anthropological acclamation of freedom is no novelty. So early as 1843 Klemm conceptualized the three stages of human progress as *Wildheit*, *Zahmheit* and *Freiheit*. The social scientist can never hope to be entirely detached, and it is arguable how far he can, or should, avoid imposing his own value-judgments upon the material of his study. My own feelings, in the present instance, are that it would need only a slight recasting of Malinowski's argument to demonstrate that totalitarian Russia rather than democratic America is the true heir to the 'proto-democracy' of archaic primitives, and this makes me suspicious of the whole procedure. Yet in some ways the attempt is magnificent. Towards the end of his book Malinowski claims that "the scientific indication of freedom attempted in this analysis vindicates all our personal preferences, the dictates of our common sense, and of our moral sense also, since it shows in cold dispassionate analysis that our democratic regime is a sound mechanism of progress, while totalitarianism must inevitably kill not only freedom, but also the gift which it has given humanity, that is, culture" (p. 317). The analysis is neither cold nor dispassionate; yet it is dogmatic optimism of this sort which will one day make possible a true humanist civilization.

E. R. Leach

HISTORY OF ANÆSTHESIA

Victory over Pain

A History of Anesthesia. By Dr. Victor Robinson. Pp. xiv+338+30 plates. (London: Sigma Books, Ltd., 1947.) 16*s*. net.

THE discovery of anæsthesia, the centenary of which has just been celebrated, was one of the most important happenings in the history of mankind. The publishers of the volume under notice did well to produce it with such care and in such satisfying style; Dr. Robinson has appreciated the magnitude of his task and has magnificently overcome many of the difficulties that beset the historian of his subject. Indeed, the first two thirds of his book are excellent. Rapidly reviewing and rightly dismissing the stories of classical and medieval 'anæsthesia', he describes the unhappy years between 1799 and 1846 in graphic studies of Davy, Hickman and Wells, each of whom scored a 'near miss' on the target of painless surgery. Then follows the triumphal story of Morton's demonstration on the morning of October 16, 1846. This was a tremendous event; Dr. Robinson presents it calmly but with firm insistence on its importance. There follow descriptions of Jackson, the would-be 'spiritual father' of the discovery, and of Long, who had practised etherization as early as 1842 without troubling to inform a pain-racked world. These are a mild anticlimax as compared with the actual descent from the heights into the infamous and damnable 'ether controversy' which arose between Morton, Jackson and Long. As a storyteller, Dr. Robinson is no doubt right to dismiss what is beneath contempt as also beneath notice; as a historian, he is wrong.

It appears that we have heard too much of how Simpson over-stated his claim to be the 'discoverer' of chloroform (and, by an implication natural in Great Britain, of anæsthesia itself). Dr. Robinson treats these pretensions very gently indeed; so much so, that we are scarcely surprised later to find that Benjamin Ward Richardson is given more space and praise than the recorded facts would seem to justify. ("Is there no offence in't?" "No offence i' the world.") New matter, new at very least to histories of anæsthesia, appears in the account of Samuel Guthrie, the backwoods chemist who apparently should share the chloroform glories of Dumas, Liebig and Soubieran. Dr. Robinson proceeds to develop his general theme by particular accounts of the men who led the way. Excellent though this method was in the beginning, it is hopelessly inadequate as the subject expands and ramifies. So many men took part in discovering agents, devising instruments and developing methods that there is no middle way between a catalogue of names or an inconsequent selection; in this instance we are presented with the latter.

In the end, Dr. Robinson gives us an inadequate description of anæsthesia's newest ally, the muscular relaxation obtainable by the use of curare. This is followed by a rhapsodic and almost incoherent epilogue of praise and exhortation. Had the author contented himself with describing pre-anæsthetic days and the events which led up to the discovery of ether anæsthesia, he would have given us a notable work. We have, however, one which starts well, continues magnificently, but ends in an inconclusive and aimless flurry. G. EDWARDS

PURE AND APPLIED SEISMOLOGY

When the Earth Quakes

By the Rev. James B. Macelwane. (Science and Culture Series.) Pp. xiii+288. (Milwaukee: Bruce Publishing Co., 1947.) 5 dollars.

IN 1944 the Institute of Geophysical Technology was established at St. Louis, U.S.A., in co-operation with the University, and Father Macelwane was chosen as its dean. For one so well versed in the basic subjects of geology, physics and mathematics, this was a well-merited honour; and in so short a time as 1944–47 dividends have been paid. "By their fruits ye shall know them" has been well borne out, for out of the St. Louis Institute of Geophysical Technology, based on work by J. J. Shaw in England, has come the new use of the seismograph as a meteorological instrument via the study of micro-seisms by Father Ramirez. Father Macelwane and his colleagues at St. Louis are about to take this work a step further by setting up sensitive micro-barographs at the angular points of a triangle of several hundred feet side in order to trace the paths of microbarographic storms, and for this work the weather-minded U.S. Navy has assisted with a grant of 25,000 dollars.

After writing so many technical papers and books on geophysics and its associated subsidiary subjects, Father Macelwane, while in the midst of his work, has at last been persuaded to write a book on seismology for the general reader. Seismology deals not only with earthquakes as they are felt, but also with the nature and causes of earthquakes and their relation to other geological processes in the earth. It deals with the effect of earthquakes on structures built by man and with all the problems of engineering that arise from them. It includes the physics of earthquake waves propagated through and round the earth, and the knowledge these give us of the earth's interior. It treats of man-made earthquakes, the vibrations caused by blasts of explosives, and their use in determining the hidden make-up of the earth's outer shell, thereby assisting in the location of valuable mineral deposits, especially petroleum. The book covers the whole field of pure and applied seismology, and Father Macelwane is to be congratulated on compressing so much material, while keeping it readable, into so small a space. Many natural earthquakes, their supposed causes and their effects are described, together with the manner in which they are studied macroseismically in the field and by means of instruments. Sea quakes and seismic sea waves are discussed, and there is a chapter on earthquake noises following Davison. The engineering aspect in such subjects as earthquake-proof design is not overlooked, and there are chapters on rock bursts and also on seismic prospecting.

A glossary is provided to enable the reader to come to grips with some technical terms, and this will undoubtedly help. There are a full list of references in addition to acknowledgments, and a good index. The text is interspersed with numerous good clear diagrams as well as photographs as illustrations in a book which is a joy to handle after the 'austerity' books of present-day Britain.

E. TILLOTSON

ARCHÆOLOGY AT OXFORD

Archæology and the History of Europe

An Inaugural Lecture delivered before the University of Oxford on 28 November, 1947. By Prof. C. F. C. Hawkes. Pp. 24. (Oxford: Clarendon Press; London: Oxford University Press, 1948.) 2*s*. net.

IT is indeed excellent that the University of Oxford has created a chair of European archæology, and that Christopher Hawkes has been selected as its first occupant. The University will gain lustre from his learning, and he will have scope to work out in practice the very definite ideas about the orientation of his subject which he sets forth in this lecture. It is indeed well that the various universities interested in archæology should not all place it in the same setting or look at it from the same point of view. Prof. Hawkes says, for example, that archæology "is not a subject in its own right, as are History, Philosophy, or, say, the Biological Sciences". As a Cambridge archæologist, I can only ask, "Why not?" Biochemistry is considered as a separate subject, and yet it only recently hived off from its parent sciences. Prehistory and archæology have similarly hived off from geology and early history, but surely can by now be classed together as a single subject worthy of an honours school.

Again, Prof. Hawkes says that for him archæology belongs to history, not simply in operational practice but in philosophical theory likewise. It is excellent that this aspect of the subject should not be forgotten, and Oxford is probably the appropriate place where it should be particularly enunciated. But there is also the possibility that archæology—more especially in its early phases—can be considered scientifically, and that it is the scientific approach to the subject which should be stressed and which indeed adds much to its charm.

As was to be expected, Prof. Hawkes has given a most interesting and thought-provoking inaugural lecture, couched in the inimitable literary style we have come to expect from him and his University, and enlivened by some charming touches, as when he self-deprecatingly refers to himself as being pegged out over so large an acreage of professorial territory that he fears his thinly outspread vitals will offer but little sustenance to the birds! But when we have considered his ideas on the scope and disciplines and duties of his subject, we can only reassure him that his fears are groundless. We look for great things from him in this new chair with his particular way of surveying his domain. For the last thirty years the Cambridge school has stressed the scientific and anthropological approach to archæology: it will be interesting and valuable to see a school grow up at Oxford on the lines suggested in this lecture. If our sister university is late in the field with her chair, she could not have dignified it with a more happy choice of a first occupant. MILES BURKITT

Microcalorimetry

By Prof. W. Swietoslawski. Pp. x+199. (New York: Reinhold Publishing Corporation, 1946.) 4.75 dollars.

THE author is professor *in absentia* of physical chemistry of the Institute of Technology, Warsaw, and senior fellow, Mellon Institute, Pittsburgh.

In the monograph under notice he reviews the methods which have been used for measuring small amounts of heat. Such methods find application in physics, physiology and kindred subjects. The reader will find it a valuable reference work when faced with a problem in micro-calorimetry, for in successive chapters information is given on the micro-calorimeters used in radiology; the use of the ice calorimeter in microthermal measurements; calorimetry of processes of short duration; adiabatic micro-calorimeters; and labyrinth flow calorimeters. To facilitate references to original sources of information, the author has collected 130 references to published work on the subject.

Throughout the book, stress is laid on the value of comparative measurements. Such methods may involve: (1) using twin calorimeters and in compensating the heat developed in one calorimeter by electrical energy introduced into the other; (2) carrying out two successive measurements in one calorimeter, so as to produce the same thermal effect by an electric current as that developed by the object under examination; (3) using two series of successive measurements as mentioned above, with the difference that in one experiment the heat is developed by the object only, and in the other by the object and an electric current; (4) comparing the heat liberated by the object with that produced by a standard substance. The use of all these methods is described in the book.

The author has had an extended experience in the development of micro-calorimeters, and his critical comments on the various designs constitute a substantial contribution to the subject.

EZER GRIFFITHS

Between the Planets

By Fletcher G. Watson. Pp. v+222.

The Story of Variable Stars

By Leon Campbell and Luigi Jacchia. Pp. v+226.

Galaxies

By Harlow Shapley. Pp. vii+229.

(Harvard Books on Astronomy.) (London: J. and A. Churchill, Ltd., 1947.) 18*s*. each volume.

THESE three volumes belong to the well-known series of Harvard Books on Astronomy. The first and second were published in 1941, the third in 1943; reprints of all three have been required, and some additions have been made to the second. The Harvard College Observatory is to be congratulated on its enterprise in arranging for the publication of a series of eight books, all by members of its staff, which together provide a comprehensive and up-to-date survey of astronomy. Each book is written by an authority in its particular field, is abundantly illustrated, and is well printed. The series has gained a well-merited success. Though intended primarily for students, teachers and amateurs, the books are useful also to the working astronomer for reference purposes, as recent developments in the respective fields are dealt with.

The first of the three volumes under notice is concerned with the minor planets, comets, meteors and the zodiacal light. The second deals with variable stars, including novæ and eclipsing variables. The third includes a detailed account of the Magellanic Clouds, of the Milky Way considered as a galaxy, and of the neighbouring galaxies; the more remote galaxies are then dealt with, and finally the problem of the interpretation of the red displacements of the lines in the spectra of the distant galaxies is discussed.

H. S. J.

A Text Book of Physical Chemistry

By Dr. N. C. Sen Gupta and K. C. Sen. New edition. Pp. xv+526. (Calcutta: Mondal Brothers and Co., Ltd., n.d.) 10 rupees.

THIS is an interesting survey of physical chemistry up to the pass B.Sc. standard and a little beyond in places. It deals with the usual subjects, thermodynamics being given special prominence. In the section on electrolytes, activity coefficients are developed and used, and the treatment is modern. The sections on atomic and molecular structure are good. There are collections of questions and problems, with answers, and suggestions for further reading.

Although intended primarily for Indian students, this book is a very useful review of modern physical chemistry in reasonably small compass which would be quite suitable for most courses in the subject elsewhere. No serious errors were noticed beyond the statement (p. 98) that no work is done in Joule's experiment because the gas rushes into a vacuum. This is a common error; the fact is that the change occurs in a rigid vessel and so external work cannot be done. The book is well printed and illustrated on good paper, the production being Indian, but the binding is not so good.

The Theory of Valency and the Structure of Chemical Compounds

By Prof. P. Rây. (Cooch-Behar Professorship Lectures for 1941.) Pp. vii+82. (Calcutta: Indian Association for the Cultivation of Science, 1946.) n.p.

THESE lectures deal with the development of the theory of valency from its origin to the latest quantum-mechanical views on the subject. The subject is discussed concisely, but the exposition is clear and interesting. Some of Prof. Rây's own work is dealt with, and there is a useful bibliography.

Wonder of Wings

A Book about Birds. By Nancy Price. Pp. 253+16 plates. (London: Victor Gollancz, Ltd., 1947.) 14*s*. net.

A PLEASANT book is this, a volume of chat, gossip and discussion concerning birds, bird matters and problems. It is a book that can be picked up and put down, and picked up again, to dip into here, there and anywhere, the reader each time finding something new, readable and interesting. Many of the chapters are dialogues between Miss Price and her neighbour, "the Birdman", their discussions ranging over a wide variety of bird topics, from how the gods punished the raven for its sins by turning it a sombre black, to legends concerning the wren, and the story of the willow pattern plate. The author is a little confused with regard to Capt. Knight's well-known eagle, "Mr. Ramshaw", which she refers to as a martial eagle. Capt. Knight had a martial eagle; but "Mr. Ramshaw", hero of many travels and adventures, was a golden eagle of Scottish origin.

FRANCES PITT

ADSORPTION AND HETEROGENEOUS CATALYSIS*

By Prof. ERIC K. RIDEAL, O.B.E., F.R.S.

We now recognize two forms of adsorption: that in which the dispersive forces alone are operative—the so-called van der Waals or physical adsorption—and adsorption in which an electron switch has taken place between adsorbent and adsorbate—chemi-sorption. It is important to obtain criteria for distinguishing between these two forms so that we can identify the type or types involved in any particular case of heterogeneous catalysis.

The literature concerning adsorption is very voluminous, and we may refer to Brunauer's recent volume on physical adsorption to get an idea of its magnitude and extent. Here we merely observe that if we are to obtain a complete picture of such adsorption, more attention will have to be paid to the forces operative with different and definite substrates. A commencement has already been made, but we require more systematic investigation of the adsorption of polarizable and non-polarizable adsorbents on substrates which are respectively ionic, covalent and metallic in lattice structure. One may cite as an example of the former the adsorption of the rare gases on one hand, and of iodine on the other, on crystalline potassium chloride, whereby the theoretical treatment can be examined in the light of experimental data. As an example of the latter, we may mention the experimental work on the adsorption of vapours at the surface of liquid mercury, which reveals the shortcomings of the various theoretical expressions which have been derived for such interactions with metallic surfaces.

Apart from the complications introduced by the fact that the adsorbing surface is scarcely ever uniform, it is by no means improbable that many cases of physical adsorption on what is believed to be a metallic substrate may well be taking place on the top of a chemi-sorbed monolayer such, for example, as hydrogen on tungsten, on which there is already a chemi-sorbed monolayer of gas such as tungsten oxide or tungsten hydride. The slow uptake of gas which results on the admission of a gas to a bulb containing finely divided reduced metal, or other solid, may be due to the formation of a chemi-sorbed layer on its surface, or to a process of solution and diffusion into the interior of the solid. The data derived from a study of the kinetics of such processes have been interpreted on a basis both of 'activated' adsorption and of 'activated' diffusion. It is clearly important to be able to distinguish between these two different processes, since either of them might prove to be the controlling reaction in a case of heterogeneous catalysis. Valuable information may be obtained by studying the processes on surfaces freshly prepared *in vacuo*. So far, tungsten wire and mirrors of other metals deposited by thermal evaporation have been employed.

Different physical methods are available for examining the surface properties of a wire or a mirror. Thus the accommodation coefficient for a gas, the heat change, the thermionic and photo-electric properties all provide information on the presence or absence and, indeed, on the structure also of chemi-sorbed monolayers.

Such experiments reveal the fact that many cases of slow uptake of gas, which had been attributed to the chemi-sorptive process, possessing a definite and large energy of activation, were in reality due to other causes; for example, solution or displacement of one surface layer by another, since the chemi-sorptive process proceeded on the clean metal surface without any appreciable energy of activation.

While there may be some doubt in particular cases as to the exact magnitude of the energy of activation involved, it is relatively small compared to the bond-strengths of the ordinary diatomic gases which undergo dissociation on chemi-sorption. The metal-electron substrate must act in a manner analogous to a free radical. That an electron switch has taken place during chemi-sorption is revealed by the strong dipole character of the chemi-sorbed complex; for example,

$$\overset{-}{\mathrm{W}}\,\overset{+}{\mathrm{CS}} \text{ or } \overset{+}{\mathrm{W}}\,\overset{-}{\mathrm{O}},\ \overset{+}{\mathrm{W}}\,\overset{-}{\mathrm{H}}.$$

In several cases, for example, oxygen and ethylene, the reacting electron is probably the π-electron of the adsorbate; whereas many catalytic metals, for example, those in the transition group, have a narrow *d*-band overlapped by a broad *s*-band of electron-levels, and it is possibly an electron-level in this band which is involved. While a number of experiments have been carried out to determine the thickness of metal required for the emergence of 'metallic' characteristics, the great experimental difficulties involved in maintaining the substrate, in the effects of surface tension, in formation and preservation of a thin continuum in lattice form, have so far hindered progress in this direction. It is possible that further advances in our knowledge of the nature of the chemi-sorbed complex may come through physical examination of such systems, for example, the determination of specific heats of surface films, of the dielectric constant and para- or dia-magnetic susceptibilities. Experimentally, such investigations are proving to be within the compass of modern technique.

One of the most important problems connected with adsorptive phenomena is that concerning surface mobility. Under what conditions are adsorbed layers, held by dispersive forces and chemi-adsorbed layers respectively, mobile over the surface? The surface field is an undulating periodic one, and movement from one site to another may involve evaporation and recondensation, or movement over a potential hill. The adatom or adion may be raised into a migratory level. Here it may be free to move all over the surface, or may be limited to flight in one line only. It may move only into the next trough, or have a relatively long range of flight. We can develop equations to satisfy each of these conditions, but the experimental evidence so far is too inexact and too scanty to make any decision.

In the case of the alkali metals on tungsten, the data favour the view that the ion in the migratory level is restricted to a linear path and can traverse several tungsten atoms before terminating its flight. The growth of crystals from the vapour phase and the migration of organic molecules and metallic atoms

* Substance of a course of three lectures delivered at the Royal Institution on February 12, 19 and 26.

over glass surfaces provide further evidence for lateral mobility. Such evidence as is available at present suggests that lateral mobility of physically adsorbed molecules, but not of the chemi-sorbed species, can occur within the range of temperature at which the catalytic reactions occur. We cannot, however, eliminate the possibility of some mobility even in the chemi-sorbed species.

Several hypotheses concerning surface catalysis involve the concept of two-dimensional gas reactions. The experimental evidence available suggests that in surface reactions chemi-sorbed reactants, and not physically adsorbed reactants, are involved; thus the question of mobility becomes one of great importance. Apart from the fact that this mobility for the chemi-sorbed species appears to be non-existent or extremely limited, we must note that the adatoms have dipole moments, and as a result strong repulsive fields exist between them. It is interesting to compare this repulsive or spreading pressure of a film of adatoms where the pressure is due to a free two-dimensional gas, that is, one which obeys the formal relationship

$$F = \sigma KT,$$

where σ is the surface density of adatoms, with the pressure due to a free two-dimensional array of dipoles, that is,

$$F^1 = 4{\cdot}51\ \mu^2\ \sigma^{3/2},$$

where μ is the dipole moment. At values of $\sigma = 0{\cdot}8 \times 10^{14}$/cm.^{2} and $4{\cdot}6 \times 10^{14}$/cm.^{2}, the values of F and F^1 are for formic acid on mercury 14 and 52 dynes/cm. for F, and for potassium on tungsten 26·0 and 307 dynes/cm. for F^1 respectively. The value of the dipole moment μ likewise changes as we alter the surface density of the film, due to mutual interaction.

Examination of the heats of adsorption gives us some indication as to the extent of mutual interaction which is repulsive in the chemi-sorbed layer, as well as on the mobility of the film. It is interesting to note that, in the physically adsorbed layer, below the critical temperatures attractive forces appear to predominate; for example, in the condensation of metallic and other vapours on glass.

In the chemi-sorption of a diatomic gas such as hydrogen on the surface of a metallic lattice, the molecule undergoes dissociation to form a pair of metallic hydride molecules. If the film be immobile during the process of filling up the lattice, some eight per cent of the lattice points will be left isolated as singlets. These singlets may play an important part in heterogeneous catalysis. Two of the simplest cases of heterogeneous catalysis are the ortho-para conversion of hydrogen or deuterium and the exchange reaction between hydrogen and deuterium at the surface of non-paramagnetic metals. The reactions proceed smoothly at quite low temperatures with small but definite energies of activation. In the cases which have been examined, the metal is covered with a chemi-sorbed layer of hydride broken only by the gaps already referred to. The formal kinetics of the reaction and reference to the corresponding homogeneous reactions preclude the possibility of the reaction proceeding by a two-dimensional bimolecular gas reaction in a mobile physically adsorbed phase on the top of the chemi-sorbed atomic or hydride layer. One of the current views is that the reaction proceeds by interaction of two neighbouring adsorbed hydrogen adatoms with subsequent evaporation of the newly formed molecule. In view of the repulsive forces which we have shown to be operative and the great heat of adsorption even in a closely packed film, it is clear that many difficulties have still to be overcome before this hypothesis as to the mode of action can be freely accepted.

An alternative proposal involving an interaction between a physically adsorbed molecule situated over one of the vacant sites, and a neighbouring chemi-sorbed adatom to form a transition complex, presents us with a mechanism involving exchange of valence forces rather than rupture of any primary bonds, and goes far to overcome the difficulties associated with the other two proposed mechanisms. Many of the heterogeneous catalytic reactions can be readily interpreted by means of such a mode of action, but experimental re-examination of some of the catalytic exchange reactions is necessary before an unequivocable decision is possible.

The mechanism proposed, it will be seen, involves what is, in fact, the half-hydrogenated state which in the catalytic chemistry of the hydrocarbons has proved such a useful concept. The hypothesis of vacant sites inaccessible to particular reactants suggests their accessibility to other species, and provides us with an explanation of the broken linear character of the curves connecting poisoning with catalytic activity, an explanation alternative to a series of patches of different activity. Dissociation in chemi-sorption involves not only an electron switch, but also the problem of interatomic spacing; the relation of both these factors to the energetics of surface action provides yet another field of inquiry as yet almost unexplored. Provisional theoretical examination of the effects of surface spacing on the activation energy have not taken the electron distribution in the substrate into consideration; while attempts to evaluate energies of activation by examination of metals which form a continuous series of solid solutions and thus provide a gradual change in the mean lattice spacing, require a more detailed examination of the composition of the Gibbs surface layer and its dimensions before we can draw justifiable conclusions.

THE MAIN GEOMAGNETIC FIELD

THE main geomagnetic field and its secular variation were the subject of a Geophysical Discussion held at the Royal Astronomical Society on February 27. The largely attended meeting, at which the Astronomer Royal was chairman, was addressed by Dr. E. C. Bullard, of the Department of Geodesy and Geophysics, Cambridge (who is shortly to take up the post of head of the Department of Physics in the University of Toronto), Dr. J. McG. Bruckshaw, in charge of the sub-department of applied geophysics at the Imperial College of Science and Technology, London, Mr. D. W. Bishopp, director of the Geological Survey of Eire, and Mr. S. K. Runcorn, of the Physics Department in the University of Manchester.

Dr. Bullard outlined a new theory of the secular magnetic variation. He first recalled the main character of this variation, as exemplified by the longest series of observations, for London, which suggests a cycle of change of magnetic direction, of which about three-quarters has been completed in four centuries. Other places, however, show variations that suggest shorter periods. The accumulated data discredit the

hypothesis, formerly advanced, that these changes are due to a rotation of the geomagnetic axis about the geographical axis. Bartels has shown that the secular variation is regional in character, differing from the main field itself, which is planetary. The secular variation studies made by Fleming and Fisk, and more recently by Vestine and his collaborators, at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, show that at any one epoch the secular variation is most active in certain limited regions, but that such activity may die away in the course of a few decades, new centres of activity appearing elsewhere. These characteristics are substantiated by the occasional rather rapid changes of rate and direction of the secular variation at magnetic observatories, where the field is most accurately determined.

This time scale of the secular magnetic variation is one of its most remarkable features. Cycles of change of a few centuries in duration, and still more the observed changes during a few decades, are very rapid for a phenomenon that undoubtedly originates within the body of the earth; ordinary geological changes require millennia or even millions of years for their evolution. The rapidity of the secular magnetic variation excludes any theory based on motions or thermal changes in the solid outer portion of the earth. A deeper source must be sought, in the liquid core, the existence of which is inferred from the failure of transverse seismic waves to pass through or near the earth's centre.

Dr. Bullard discussed particularly the rapid secular variation in and near South Africa during recent decades. The isoporic charts, which show the lines of equal rate of secular change, are somewhat complicated; a clearer conception of the variation over this region is obtained by plotting the rate-of-change vectors for the horizontal component, and indicating beside them the positive or negative rate of change of the vertical component. It is still better to draw the (inclined) rate-of-change vectors of the secular variation (vertical as well as horizontal) in the median vertical plane through the region, in the direction of the horizontal change—roughly the north-west to south-east direction. Taking the region to extend over 25° or 30° in this direction (over which range the curvature of the earth is, of course, important), the vectors at the north-west end slope upward, those at the south-east end slope downward, while intermediately they are nearly horizontal.

Dr. Bullard finds that these vectors for surface points correspond approximately, in magnitude and direction, to the field of a nearly horizontal magnetic dipole situated near the surface of the earth's liquid core, below the centre of the region. The estimated moment of the dipole for the change in one year is $3{\cdot}5 \times 10^{22}$ gauss (Γ) cm.^{3}. If the change continued for a century, the equivalent dipole moment would be $3{\cdot}5 \times 10^{24}$ Γ cm.^{3}—about 4 per cent of the moment (8×10^{25}) of the earth's main field. The dipole of the secular variation may not attain this value; it may die away again within a century from the commencement of secular activity in this region, a possibility to be confirmed or negatived only by future observation in this region.

The origin of the secularly evolving magnetic dipole is attributed by Dr. Bullard to an electric current circuit, flowing in the mass of an eddy near the surface of the core; the current is supposed to be produced by electromagnetic induction by the circulatory motion in the eddy, in the presence of the permanent magnetic field. Dr. Bullard is inclined to infer that at that depth the magnetic vector is more nearly vertical than at the surface point directly overhead. He has considered, to a degree of detail not possible to reproduce here, various numerical values pertaining to the dipole mechanism; a few of his illustrative estimates may be cited. If the radius of the eddy is 300 km., the electric current intensity must be of the order 4×10^{-5} amp./cm.^{2}, the total current being about 3×10^{11} amp. The time of circulation in the eddy may be of the order 0·3 year. Under the conditions supposed to prevail at the surface of the core, where the electrical conductivity can be roughly estimated, these would be a possible set of values. The Reynolds number is estimated as 5×10^{11}; Dr. Bullard suggests that the eddy would disappear by break-up rather than by frictional decay. He considers that developing dipole fields of eddies more than a few hundred kilometres below the surface of the core would be shielded by currents induced in the upper part of the core, so that the observed secular variation at the earth's surface will be due to the uppermost core eddies.

This fascinating theoretical discussion was followed by Dr. J. M. Bruckshaw's account of some observations of great theoretical interest on the magnetic anomalies associated with the main tholeiite dykes of the north of England, a system of volcanic dykes extending from the Isle of Mull to the north-east coast of England. This work was done in conjunction with E. I. Robertson, a New Zealand research student, aided by a team of student observers. The dykes are tertiary igneous intrusions, perhaps fifty million years old; they are nearly vertical, and only 10–25 yards thick. Since their formation they have remained undistorted by any major earth movements, though displaced slightly here and there by local faults.

The vertical magnetic intensity (V) was measured at points along sixty-five traverses across the dyke; pronounced anomalies were observed, of amounts up to 2,500 γ. Each traverse gave a graph of the variations of V. Rock specimens were also taken, their orientations *in situ* being carefully noted; laboratory measurements of their susceptibility and permanent intensity of magnetization (I) thus enabled the magnitude and direction of the resultant I for the dykes to be determined. The observed anomalies in V agree well with those calculated from the size, form, position and magnetization of the dyke at various places along it. The outstanding feature disclosed by the investigation is that the dyke is magnetized in a direction nearly opposite to that of the present geomagnetic field in the locality.

Observations in volcanic regions to-day show that the magnetic lavas that well upwards as a molten magma become magnetized by induction in the earth's field as they cool through the Curie point. Mercanton, Thellier and others have shown that in many cases such rocks have great magnetic retentivity, and most of the rock specimens collected in this investigation show the same property, though in a few cases their magnetization declined appreciably within a few months. The simple interpretation of the observed data is that the earth's field in this region fifty million years ago was opposite in direction to that which now exists there. The poor retentivity of a minority of the rock specimens may explain the few cases in which the magnetization has the present direction of the field. In general, the observed

anomalous I is two to eight times as intense as the present field would induce.

Such anomalous magnetization has previously been observed in Germany, in the Arctic (by Mercanton), in New Zealand, and (perhaps the most striking case) in the Pilansberg dykes in South Africa, which are palæozoic, perhaps two hundred to five hundred million years old. Mr. D. W. Bishopp, in his account of a recent survey of the vertical force (V) over Eire (from which two magnetic maps, not yet published, have been prepared), added further examples, also of tertiary intrusions, showing the 'wrong' sign of magnetization.

The Pilansberg dykes are not too far from the equator to exclude the possibility of explanation, in their case, by the hypothesis that in the course of the secular variation the *magnetic* equator has passed across this region, corresponding to a reversal of the local value of V. But this explanation could not be applied to regions so far north as the Border or as Eire. It is difficult also to see how Dr. Bullard's explanation of the secular variation could account for a local reversal of the field. Geologists present at the discussion remarked that in tertiary times the molten layers seem to have come unusually near the surface; but it is not clear how this could help to explain a reversal of the field. A very extensive continental drift carrying great land masses across the equator is another possible but unattractive hypothesis that would obviate the conclusion that the earth's field as a whole was once of opposite polarity. This conclusion would, of course, be quite inconsistent with any 'fundamental' theory associating magnetization with rotation in the case of large rotating masses, such as Prof. P. M. S. Blackett has advocated.

The fourth contribution to the discussion, by Mr. S. K. Runcorn, bore on this hypothesis. When Prof. Blackett in May last read his paper on the 'fundamental' theory of magnetization by rotation, Dr. Bullard pointed out that the variation of the magnetic intensity with depth within the earth should provide a crucial test between such a theory, and the usual 'core' theories which assign the source of the earth's field to some cause within an inner core of the earth. Any core theory, which regards the overlying portion of the earth as non-magnetic, implies that V and H both vary as $1/r^3$ at distance r from the earth's centre, outside the core. On the fundamental theory, in which every element of mass contributes in some way to the field, the intensity might be expected to decrease downwards. The depth-variation of intensity on the fundamental theory, for different distributions of density within the earth, has since been calculated by Mr. Runcorn and also by Chapman; it appears that near the surface V varies as $1/r^3$ whatever the density distribution (assumed spherically symmetrical), so that measurements of the depth variation of V cannot distinguish between the fundamental and the core theories. The 'fundamental' depth-variation of H, however, is a downward decrease, depending on the density distribution; this therefore, as Dr. Bullard suggested, offers a possibility of deciding between the two theories.

Observations of H in South Africa at an effective depth of 4,800 ft. in a Witwatersrand mine have recently been reported in *Nature* (**160**, 746; 1947); they show a decrease, favouring the fundamental theory; but there is great need of further measurements in regions less disturbed magnetically than the Witwatersrand. Mr. Runcorn gave a preliminary account of such measures in a coal-mine at Leigh, in Lancashire, in a region apparently devoid of any appreciable magnetic anomalies. He, Mr. A. C. Benson and Mr. S. Goldsack, of the University of Manchester, have measured both V and H at a depth of 4,000 ft., in a disused working, well removed from any iron or steel mining structures. Comparison with V and H measured at the surface show the expected downward increase of V, and a *decrease* in H; $\Delta H = -45\,\gamma$ approximately, as against $\Delta H = +13\,\gamma$ as expected on the core theory. An intensity of magnetization of 0·08 Γ/cm.³ in the top layer 4,000 ft. deep would be needed to account for this value of ΔH, and this layer is certainly not so magnetized (and if it were, V would also be affected by it).

Prof. Blackett pointed out the great importance of such observations, which if verified would indicate a hitherto unrecognized property of matter which is not magnetic in the ordinary sense of the word. Prof. T. G. Cowling remarked on the indefiniteness of the concept of angular momentum in connexion with fundamental theories of magnetization by rotation, and Prof. Blackett agreed that such theories must at present be regarded only as provisional.

The whole discussion showed that this relatively old science of geomagnetism remains lively and vigorous, and the new contributions made by Prof. Blackett and Dr. Bullard will undoubtedly provide much stimulus to further observations and their interpretation.

S. CHAPMAN

STRUCTURE OF AN ANIMAL VIRUS

By DR. I. M. DAWSON and DR. A. S. McFARLANE
National Institute for Medical Research, Hampstead, London

BECAUSE of their crystallinity, a great deal is known about the ultimate chemical structure of the plant viruses, whereas little or no corresponding information is available for the animal viruses. Efforts to obtain X-ray diffraction patterns have not been successful, and attention has been turned in recent years towards the electron microscope as the tool most likely to solve the problem. For obvious reasons attention in the first instance has been directed to the larger animal viruses, but with the exceptions of nuclei-like bodies in the Rickettsiæ[1] and less definite internal bodies in the pox group[2,3], this technique has also proved disappointing. It is clear on the practical side that the size and density of the infective particles is such that 100-kV. electrons can only just penetrate them, and any internal differences in electron density which may exist must be of a low order—probably less than 20 per cent.

In the pox group of viruses, outlines of a central body were first seen by Green *et al.*[2], with vaguer indications of the presence of four satellite bodies occupying the corners of the brick-shaped particles. The viruses of this group are all purified by differential centrifugation from dilute buffer suspensions, and it is a common experience[4,5], especially with vaccinia, to find structureless material present in the background of the electron micrographs—sometimes linking neighbouring particles as if by gelatinous bridges—which persists after repeated differential centrifuga-

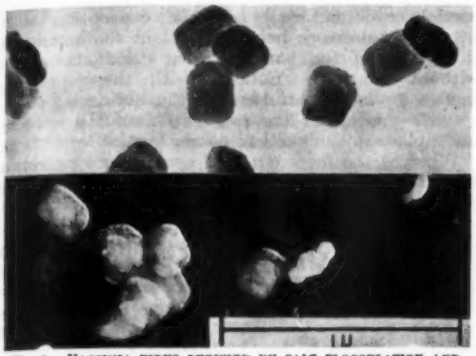

Fig. 1. VACCINIA VIRUS PURIFIED BY SALT FLOCCULATION AND FIXED WITH OSMIC ACID. ABOVE, UNSHADOWED; BELOW, LIGHTLY SHADOWED WITH GOLD TO REVEAL SURFACE STRUCTURE. SCALE INDICATES 1μ

tion. Increase of salt concentration leads to flocculation of the virus, which with vaccinia in molar sodium chloride in the cold is complete in one to three days. As an indication that some purification has been effected, the flocculum which settles out is free of the slight but tenacious pigmentation of the original virus. The supernatant is still faintly turbid and contains in particulate and soluble forms 30–40 per cent of the original virus, with roughly proportionate amounts of nitrogen, phosphorus and desoxyribonucleic acid. After repeated washing with distilled water to remove the last trace of salt, the flocculated virus can be quantitatively redispersed into dilute buffer with the aid of sonic or ultrasonic vibrations[6]. The infectivity is not seriously reduced by the treatment, the virus having been passed through several host animals with exhaustive sodium chloride extraction and sonic resuspension at each passage.

Electron micrographs (Figs. 1, 3) show a complete absence of background material in the salt-extracted virus. Occasionally one or two particles are visible standing on edge (Fig. 1) and revealing a thickening at the centre and smaller ones at the corners. Consideration of the blackening caused by one particle overlapping another in conjunction with the shape of the particles suggests that the dark areas seen in the transmission pictures at the centres and corners of the bodies can be explained sufficiently by the geometry of the particles without invoking internal differences in scattering capacity. The relative sharpness of the edges of the central areas, however, is difficult to reconcile with this view.

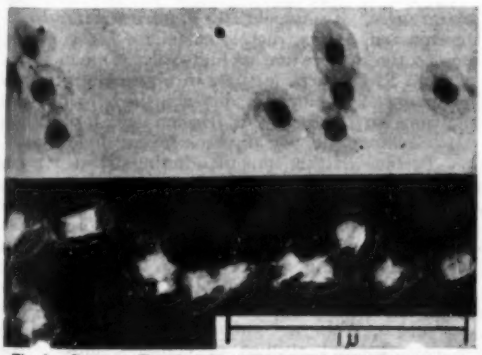

Fig. 2. SAME AS FIG. 1, BUT AFTER PEPTIC DIGESTION OF THE VIRUS

Digestion with pepsin is known to be a useful adjunct to alkali in removing the nucleic acid from vaccinia[7] and we have, therefore, made an electron microscopical investigation of the action of this enzyme. Incubation of the virus at *p*H 3·0 and 37° C. for several hours causes no visible alteration in it; but in the presence of a few micrograms of crystalline pepsin three-quarters of the virus substance goes into solution in half an hour. Micrographs of the residual particles (Fig. 2) show that the central body is certainly not an artefact. No traces of satellite bodies are seen, however, indicating that the dark areas in the corners are to be identified with local thickenings of the virus substance, or with intracellular particles which, unlike the central ones, are hydrolysable with pepsin.

The action of pepsin is complete in half an hour, practically all the phosphorus and desoxyribo-nucleic acid of the salt-extracted virus being retained in the residue. Incubation of this with desoxyribo-nuclease (kindly supplied by Dr. M. Kunitz, Rockefeller Institute, Princeton, N.J.) at *p*H 7·5 for 1 hr. results in liberation of the nucleic acid in soluble form. This treatment does not seriously alter the architecture of the residual cell, but some loss of density occurs in the central body. These observations show that

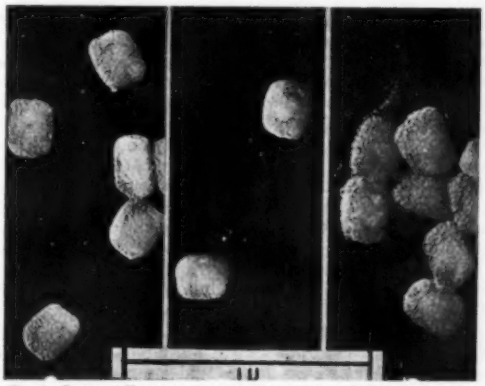

Fig. 3. SAME AS FIG. 1, BUT MORE HEAVILY SHADOWED WITH GOLD

this body has some, at least, of the characteristics ordinarily attributed to a nucleus, and seem to justify the use of this term for it. It is, of course, of an altogether lower order of size (*c.* 90 mμ diameter) than anything hitherto designated as such, and the term is used without any implication that this virus nucleus is capable of subdivision in any genetic sense.

Folds are clearly visible in the perinuclear part of the pepsin-digested virus (Fig. 2) and also in ghosts of the virus obtained by the action of sodium hydroxide[8]. These are similar to the folds seen in erythrocyte ghosts[9] and seem to argue convincingly in favour of the presence of a thin limiting membrane. The resolution of the electron microscope is not sufficient to identify a pattern in the substance of the membrane with any certainty. Gold-shadowed pictures (Figs. 1, 3) of the salt-extracted virus, however, show a granularity of a higher order than that seen in the background and which at some places on the virus surface is remarkably regular in arrangement—presumably reflecting a close packing of protein macromolecules. We have observed occasionally in several pictures (Fig. 3) chains of apparently similar

'macromolecules' which may have been stripped accidentally from virus particles, but without any signs of correspondingly deficient areas or strips on virus bodies. These in conjunction with photographic density considerations suggest that the granularity is not restricted to the surface but has a bulk distribution throughout the perinuclear space.

Since the envelopes collapse after removal of the protein within (Fig. 2), they cannot alone be responsible for the characteristic cuboidal shape of the virus. Something more is necessary, and we may consider in this connexion two suggestions which have been put forward[9] to explain shape in larger cells, and in particular the biconcave shape of the mammalian erythrocyte. On one hand, a submicroscopic network or reticulum is envisaged into which the molecules fit and upon which they confer a rigidity ; and on the other, intermolecular attractions of the kind which hold a protein crystal together are invoked. The fundamental difference between the two views is the chemical one that in one case only protein removable by hæmolysis (or peptic hydrolysis in the case of the virus) is present, while in the other this protein is interspersed with resistant stroma protein. Practical differentiation by chemical or physical means is extremely difficult, and at least in the case of the red cell has not been satisfactorily achieved. Ponder has to conclude a recent paper[10] with the statement : "Changes in a membrane alone seem inadequate to account for the varied phenomena observed in connexion with red cell behaviour, the explanation of which appears to require a more detailed knowledge of the molecular architecture of the cell interior". At the same time he is able in this paper to provide experimental support for Teitel-Barnard's demonstration[11] of para-crystallinity in the red cell. He finds local areas of birefringence in rat red cells preserved in citrate, and this observation may be of interest in relation to the patchy distribution of particle regularity which we observe in the virus. It suggests that our first impression that a partial disorientation occurs on drying may be wrong, and, in fact, the cytoplasm of the native virus contains protein phases of different degrees of orderliness, from the loose molecular arrangement which holds in protein gels up to the perfect regularity of a protein crystal.

With regard to the alternative stroma hypothesis, evidence is available, mainly from studies of form birefringence, for the existence of submicroscopic fibrils in the cytoplasm of cells, for example, of retinal rods[12] and egg cells[13]. Two pieces of evidence, neither of them conclusive, favour the existence of a fibrillar arrangement in vaccinia. It is noticeable after peptic hydrolysis that the nuclei are almost always centrally placed in the cell as if held there by an invisible net. The second point is derived from considerations of the shrinkage which occurs on drying. Virus particles from which the water has been sublimed at −70° C. have major dimensions 250 mμ by 200 mμ with ± 5 per cent individual variations. The mean thickness as measured at the periphery from profile views and shadow lengths is estimated to be 110 mμ. Drying at room temperature causes a reduction in the mean thickness to one half without giving rise to any appreciable alteration in the other two dimensions. Treatment with osmic acid, on the other hand, followed by drying at room temperature, causes a uniform shrinkage of 20 per cent in all dimensions. The latter behaviour is explained by protein fixation on any hypothesis of particle architecture ; but the conception of a supporting network helps to explain the manner of subsidence of the particle when dried above zero without fixation. Contact with the supporting surface prevents shrinkage in the horizontal plane, while a concertina-like contraction of the network takes place in the vertical plane.

Whereas the facts outlined here do not provide a complete picture of the structure of vaccinia, they establish that it is definitely more complex than that of the fully crystalline plant viruses. On other grounds, Anderson[14] is inclined to identify this virus structurally with the bacteria. A major difficulty which we have in accepting this is that so little is known about the interna! organisation of bacteria in spite of their much larger size. It is doubtful, for example, whether the controversy surrounding the existence of nuclei in the accepted cytological sense in bacteria has ever been livelier than at present[15], and curious new structures are coming to light as a result of phage studies[16]. In a preliminary way we have subjected a bacterium (*Proteus vulgaris*) to the action of molar sodium chloride followed by pepsin, and observed that the effects are different both qualitatively and quantitatively from those encountered with vaccinia.

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NEW FELLOWS OF THE ROYAL SOCIETY

AT the meeting of the Royal Society on March 18, the following were elected to fellowship :

Dr. T. E. Allibone, director of the Research Laboratories of Associated Electrical Industries, Aldermaston, Berks, distinguished for his contributions to the application of high-voltage phenomena.

Dr. F. P. Bowden, lecturer in physical chemistry, University of Cambridge, distinguished for his contributions to the study of friction and lubrication.

H. Constant, deputy director (research), National Gas Turbine Establishment, distinguished for his studies in the applications of thermodynamics and aerodynamics to aircraft engines.

Dr. S. F. Dorey, chief surveyor, Lloyd's Register of Shipping, distinguished for his contributions to marine engineering.

E. H. Farmer, assistant director and senior organic chemist of the British Rubber Producers' Research Association, Welwyn Garden City, distinguished for his experimental studies of complex unsaturated hydrocarbons and related natural products.

Prof. O. R. Frisch, Jacksonian professor of physics in the Cavendish Laboratory, Cambridge, distinguished for his researches on fission processes in nuclear physics.

Sir John Fryer, secretary of the Agricultural Research Council, distinguished for his services to agricultural science and his contributions to applied entomology.

Prof. T. M. Harris, professor of botany in the University of Reading, distinguished for his researches in palæobotany.

Prof. W. H. Heitler, senior professor in the School of Theoretical Physics, Institute for Advanced Studies, Dublin, distinguished for his contributions to theoretical physics.

A. L. Hodgkin, assistant director of research in physiology, University of Cambridge, distinguished for his researches on the nature of nervous conduction.

Dr. G. M. Lees, chief geologist to the Anglo-Iranian Oil Company, distinguished for his contributions to stratigraphical and structural geology, particularly in relation to oilfields.

Prof. R. A. McCance, professor of experimental medicine, University of Cambridge, distinguished for his contributions to metabolic studies of human beings.

Dr. K. Mahler, senior lecturer in mathematics in the University of Manchester, distinguished for his researches in the theory of numbers.

Dr. Sidnie M. Manton, lecturer at King's College, London, distinguished for her work on the Crustacea and other invertebrates.

Dr. Dorothy M. Needham, of the School of Biochemistry, University of Cambridge, distinguished for her researches on the biochemistry of muscle.

Prof. J. H. Orton, professor of zoology, University of Liverpool, distinguished for his investigations in marine biology.

Sir Leonard Parsons, emeritus professor of diseases of children, University of Birmingham, distinguished for his studies on child health and the wasting disorders of children.

Dr. Stanley Peat, reader in organic chemistry, University of Birmingham, distinguished for his contributions to the constitution and synthesis of carbohydrates.

Prof. G. W. Robinson, professor of agricultural chemistry, University College of North Wales, Bangor, distinguished for his contributions to the study of soils.

Dr. W. A. H. Rushton, university lecturer in physiology, Cambridge, distinguished for his researches on the effect of electrical stimuli on muscles and nerves.

J. W. Ryde, senior physicist in the Research Laboratories of the General Electric Company, Wembley, distinguished for his contributions to pure and applied physics.

G. R. S. Snow, fellow of Magdalen College, Oxford, distinguished for his work on plant hormones and growth.

Dr. E. W. R. Steacie, director, Division of Chemistry, National Research Council, Canada, distinguished for his researches on gaseous chemical reactions.

Dr. J. A. Todd, lecturer in mathematics, University of Cambridge, distinguished for his researches into the geometry of figures.

Dr. F. Yates, chief statistician, Rothamsted Experimental Station, distinguished for his contributions to the statistical analysis of agricultural problems.

NEWS and VIEWS

Mathematics at Leeds: Prof. S. Brodetsky

THE retirement has been announced of Prof. S. Brodetsky, professor of applied mathematics and head of the Department of Mathematics in the University of Leeds. It must be but rarely that the career of any distinguished scientific man borders on the romantic, but the career of Prof. Selig Brodetsky certainly furnishes one of these rare cases. He was born sixty years ago of orthodox Jewish parents at Olviopol, a village in Russia near Odessa. The prevalence of pogroms against the Jews in the Russia of those days decided the father to seek an asylum for himself and his family in England. He left Russia by himself first of all, and after he had established a means of livelihood in London, he sent for his wife and four children to join him. It was an adventurous journey across Europe for a young woman with four young children, and Brodetsky has frequently told how, as a child of four years of age, he clung to his mother's hand while crossing a frontier, while she pushed a corner of her shawl into the mouth of his little sister in arms to prevent her crying and so attracting the attention of the frontier guards. The number in the family increased steadily in London and the *res angusta domi* was never far absent from their home. But Brodetsky's father was a man mighty in the Scriptures and particularly well-versed in the Talmudic writings, so that young Selig was reared in a home pervaded with traditional Jewish culture and an intellectual outlook although in a restricted field. The result was that several of the children overcame all obstacles and entered universities.

Brodetsky was educated at the Jews' Free School and at the Central Foundation School, London. He entered Trinity College, Cambridge, and was Senior Wrangler in 1908, a feat on the part of a Russian-born boy which evoked much interest and astonishment at the time. After five years as a lecturer in the University of Bristol he joined the mathematical staff at the University of Leeds and became professor of applied mathematics there in 1924. Prof. Brodetsky's twin interests through life have been applied mathematics, particularly aerodynamics, and the cause of the Jewish people. He has been an indefatigable worker for Zionism. As a university teacher, he was a brilliant expositor of mathematical subjects, both on the academic platform of the university and to lay bodies outside its walls. He carried out much research work and wrote several mathematical treatises. Brodetsky is a man of great bodily vigour and unquenchable vitality. His knowledge of Europe and foreign affairs generally made him invaluable in shaping university policy both inside Leeds and more generally in consultation with his colleagues in other centres of learning. His fruitful activities in university life will be seriously missed.

Prof. H. S. Ruse

PROF. H. S. RUSE, who has succeeded Prof. S. Brodetsky as head of the Department of Mathematics in the University of Leeds, was an undergraduate at Jesus College, Oxford, during 1924–27. After spending nearly ten years as a lecturer on the mathematical staff at the University of Edinburgh, he became professor at University College, Southampton, in 1937 and he remained there until he went to Leeds in 1946 as successor to Prof. W. P. Milne on his retirement from the chair of mathematics. In 1931 Ruse spent a period in Rome working with the late Prof. Levi-Cività, and in 1933–34 he was on leave of absence from Edinburgh working with Prof. Oswald Veblen at the University of Princeton. Prof. Ruse's main interest is relativity and tensor analysis and he has published a great many original papers in this field in the leading mathematical journals.

In the University of Leeds with its large number of applied science departments, the Department of Mathematics occupies a focal position, and it has a great contribution to make to the work and development of the technological departments. There is a long tradition in the University of a close and cordial co-operation between the Department of Mathematics and the applied sciences, and *ad hoc* courses in mathematics suitable for the individual needs of the technological departments and the Medical School have, so far as the size of the mathematical staff permitted, for long been provided. Prof. Ruse is in complete sympathy with this liaison between the pure and applied sciences, and intends to develop it still further. The Department of Statistics under the readership of Dr. B. L. Welch is within the Department of Mathematics, and this fruitful relationship is already being felt throughout the University in the development of statistical methods. There is a movement afoot for co-operation being established between the universities of northern England in the systematic pursuit of mathematical research, and this activity also has Prof. Ruse's warm support. It need scarcely be said that, in addition to the above affiliations, the cultivation of the science of mathematics for its own sake will be vigorously pressed forward under the leadership of the new head of the Department of Mathematics in the University of Leeds.

Prof. T. G. Cowling, F.R.S.

PROF. T. G. COWLING, who succeeds Prof. Brodetsky in the chair of applied mathematics at the University of Leeds, received his mathematical university training at Brasenose College, Oxford, and in 1931 was awarded the D.Phil. degree for a thesis dealing with the magnetic field of the sun and the radiative equilibrium of a spherical star. Afterwards he held lectureships in the mathematical departments at the Imperial College of Science and Technology, London, the University Colleges at Swansea and Dundee, and the University of Manchester, before being appointed to the chair of mathematics at University College, Bangor, in 1945. In 1947 he was elected a fellow of the Royal Society. He has written a large number of original papers on difficult problems of mathematical astrophysics, the kinetic theory of gases, the physics of the lower atmosphere and also of the ionosphere, and the magnetism of the earth, the sun and sunspots. His principal astrophysical papers deal with the stability of stellar models, the point source model of a star, convective equilibrium in stellar interiors, and the density distribution within stars as deduced from the motion of the apsidal line in close binary stars. He is also joint author with Prof. S. Chapman of the treatise "The Mathematical Theory of Non-Uniform Gases", and of a memoir on gaseous diffusion in a rare gas mixture. In this field one of his most important papers treats the problem of the electrical conductivity of an ionized gas in the presence of a transverse magnetic field. His work is characterized by great critical insight combined with constructive power.

University Representation in the House of Commons

WHEN the Representation of the People Bill now before Parliament (see *Nature*, February 21, p. 259) came up for consideration on March 16 by the House of Commons in committee, Mr. O. Peake, member for Leeds, N., moved an amendment which was one of a series designed, he said, in accordance with the words of the unanimous recommendation of the Speaker's Conference, to maintain university representation and methods of election, and to ensure that registration of university graduates should in future be automatic and free. Some of the grounds for the retention of the university vote were set out in the article referred to above, and the support they obtained, not only from university representatives but also from other members of various shades of political opinion, showed that a case could well be sustained. The Government's spokesmen, however, Mr. Herbert Morrison and Mr. Chuter Ede, confined themselves practically to two points, namely, that the Speaker's Conference recommendation, having been made during a previous Parliament, was not binding on the present Government, and that the principle of plural voting was fundamentally wrong and "not in accord with a properly conceived democracy". Mr. Ede referred to the measure as one designed to redress electoral anomalies resulting from the Act of 1918; he said he had never believed in university representation, which he described as the last of the fancy franchises. The amendment was negatived by 328 votes to 198, a majority of 130.

Institute of Metals: Past and Future

THE new president of the Institute of Metals who took office on March 17 is Sir Arthur Smout, a director of Imperial Chemical Industries, Ltd., with special responsibility for the Company's metal and ammunition interests. A member of council of the University of Birmingham, and during 1942–45 director-general of ammunition production at the Ministry of Supply, he has had a life-long experience of the non-ferrous metal industries.

As this was the fortieth annual general meeting of the Institute, Sir Arthur, after paying a well-deserved tribute to his predecessor, Colonel P. G. J. Gueterbock, devoted the first part of his presidential address to its early history. The germ of the idea of such an Institute originated with a young engineer, W. H. A. Robertson—who was present at this meeting—in a letter in *Engineering*. A preliminary meeting held in Manchester in March 1908 was adjourned to London in June of that year, when the decision to go ahead with the plan was taken. This delay proved all to the good, as otherwise the trivial and clumsy title of "Copper and Brass Institute" might have been accepted. The fear of these pioneers that the Institute might fail through the disinclination of manufacturers to allow their technical staffs to present papers or take part in the discussions has fortunately

proved groundless, and possibly one of the greatest services that the Institute has rendered to the industry is the breaking down of such prejudice and by providing a bridge across which scientific men and practical men can come into contact. The work of Shaw Scott, the first secretary and editor, received from the new president, who is in a position personally to appreciate his work, the fullest and most well-deserved praise. To Shaw Scott's guidance and devotion the Institute owes much. Among the papers read at the opening meeting in Birmingham in November 1908, Echavarri spoke of aluminium and its uses, and referred to the "enormous" demand for aluminium in 1906 and 1907 when the world production was 15,000 and 23,600 tons respectively; these figures are interesting in comparison with that of 1,890,000 tons a year at the peak of production during the Second World War.

The concluding part of the address was devoted to the future. As one concerned with both the metallurgical and the chemical industries, Sir Arthur contrasted the essentially continuous processes characteristic of the chemical industry with the 'batch' process normal in non-ferrous metal production. "To any industrial metallurgist laying down a new plant, I would commend the technical approach of the industrial chemist as worthy of close consideration." This represents the crux of the plea made for the reduction or, if possible, complete elimination of 'idle time'. Coming from one who is essentially an industrialist, it is of the greatest interest that he pleaded for the encouragement "of those who are engaged on investigations which may at present be of little or no commercial value, but which are calculated to establish the underlying general principles of the science of metallurgy". As an instance of what can be done in this direction, the aluminium light-alloy industry was quoted as a practical example.

The Royal Air Force School of Education

A NEW Royal Air Force School of Education has been opened at Wellesbourne Mountford, near Leamington Spa, and one of its main purposes is to prepare newly appointed education officers for their professional duties in the R.A.F. The School is housed for the present in temporary accommodation because in view of the nature and the importance of the work a start could not be delayed. It is intended, however, to move the School to a more permanent location when this is feasible. Education in the R.A.F. differs little in its background from education in the civilian world. Its immediate purpose is to develop those qualities of mind and character which, while adapting the officer, the airman or the boy apprentice to the exercise of particular duties, yet helps him to achieve a worthwhile personal and social life and to appreciate the duties and privileges of citizenship. On the technical side, too, it is the task of the Education Branch to contribute a theoretical content towards technical and air-crew training of R.A.F. personnel for their day-to-day duties. Naturally the means and conditions through which these tasks are performed in the Service so far differ from those outside as to involve the young education officer in a period of some difficulty until he finds his feet. It is a function of this new school of education to minimize this period, and to orientate the professional qualifications and experience of the newly appointed officer (normally a university graduate and a trained teacher, and preferably with some initial teaching experience) towards his new duties. To this end he is given instruction over a period of four weeks in the organisation and administration of R.A.F. education, in certain aspects of the theory and practice of Service teaching, in the part played by education in maintaining high standards of training and of morale, and in the methods to be employed for education in citizenship and current affairs. In addition to the lectures given by the permanent staff provision is made in the School programme for visiting lecturers of eminence in the civilian world.

It will be noted that the School lays emphasis on the scheme for the education of Service personnel in citizenship and current affairs. Indeed the School will play a part of growing significance in the further development of this scheme, and in the near future a series of courses will begin at Wellesbourne Mountford which are designed for the benefit of officers of branches other than education who may volunteer to assist in the running of discussion groups on their stations. These courses will train the officers in the technique of discussion-group leadership, and will include a factual background in citizenship and current affairs. Until the machinery of recruitment gets into its full stride, there will for some little time ahead be an acute shortage of education officers in the R.A.F. As a temporary expedient, suitable officers and others of the Service who have lesser qualifications but a liking for the work, and who volunteer for temporary duty in the Education Branch, will be accepted for duty as educational assistants—and to prepare them for this work special short courses are to be arranged for them at Wellesbourne Mountford almost immediately. They will follow the lines of the main course as for education officers, but on a somewhat lower plane. In the case of airmen volunteers, since they will be given acting non-commissioned officer rank on the successful completion of the course, training will also be given in disciplinary and other duties appropriate to the rank. Finally, it is intended that the School will, from time to time, provide specialized courses of a refresher nature to keep education officers up to date in the development of new educational techniques and of educational research.

Conference on Scientific Information Services

THE Royal Society is arranging a Conference on Scientific Information Services to be held in London during June 21–July 2. The Conference, which will consider information services from the point of view of the scientific user, in accordance with the recommendation made in 1946 by the Royal Society Empire Scientific Conference and the British Commonwealth Scientific Official Conference, will be attended by representatives of countries providing information services in English. Editors-in-chief, who will prepare memoranda as bases of discussion, have been appointed as follow for the four sections into which the Conference will be divided: Section 1, publication and distribution of papers reporting original work (Prof. J. D. Bernal); Section 2, abstracting services (Sir David Chadwick); Section 3, indexing and other library services (Dr. J. E. Holmstrom); Section 4, reviews, annual reports, etc. (Prof. H. Munro Fox). It is hoped to cover all scientific subjects, including agricultural, medical and engineering sciences. Material suggested for discussion should be submitted as soon as possible to the appropriate editor-in-chief c/o Assistant Secretary, Royal Society, Burlington House, London, W.1. Contributors are asked to

emphasize the practical steps that should be taken to implement their suggestions, including the provision of finance and the requisite personnel. Admission to the Conference will be by ticket only; applications should reach the Assistant Secretary of the Royal Society before June 1.

Institution of Mechanical Engineers: Clayton Awards

THE Institution of Mechanical Engineers has divided the Clayton Prize for 1947 in equal moieties. One half, valued at £650, has been awarded to Mr. J. E. Sears, formerly superintendent of the Metrology Department of the National Physical Laboratory, for his services to engineering science and manufacture by researches and development in metrology and gauging; the other half, to the value of £650, to Mr. T. E. Beacham, consulting engineer, for his contribution to the development of the variable-pitch propeller and high-speed hydraulic pumps and other hydraulic devices by way of research, invention and design.

A number of Clayton Fellowships are to be awarded during 1948; funds for this purpose have been derived from money bequeathed to the Institution by Mr. James Clayton, who died in 1944. Mr. Clayton was chief engineer of Messrs. Courtaulds and was closely associated with the development of equipment for the rayon industry. The Clayton Fellowships will in general be awarded for a year of postgraduate study or experience in mechanical engineering or a related science, and will be worth £250–£500. Candidates must be British-born subjects not less than twenty-three years old, and must possess an approved engineering degree or similar status.

Marketing Agricultural Produce

THE written evidence submitted to the Lucas Committee on the Marketing of Agricultural Produce by Mr. Thomas Shaw, on which that Committee largely based its recommendations for setting up a system of marketing for meat when the present rationing scheme and control by the Ministry of Food ends, has now been published, together with a foreword by Dr. John Hammond (from the author, Brettenham House, Lancaster Place, London, W.C.2). Insufficient attention has yet been given to the recommendation that producer marketing boards should continue to function only up to the point of procurement where the guaranteed price under the Agriculture Act applies, and that any participation in the functions of processing and marketing beyond that stage should fall within the ambit of a national slaughterhouse board or commission. Mr. Shaw's evidence details clearly the measures which the livestock industry most needs for efficiency, including complete reorganisation of the existing slaughterhouse set-up, utilization of all by-products and elimination of unnecessary profit margins, grading, division of poorer quality meats from the fresh, the manufacturing market and measures to mitigate seasonal variations in supplies. The proposed public corporation would be given powers to approve central factory abattoir schemes; to determine the terms and conditions under which such schemes should operate; to operate grading services at the abattoir and a price-governing formula; to authorize public funds required to implement the Government guarantee of prices, and linking that guarantee with qualities of the product; to make levies covering the cost of administration and the finance of industrial research in connexion with the abattoir; and to make loans to central factory abattoir schemes. The scheme, which is intended to lead to the effective closing of the wide gap between producer and consumer prices, to relieve the State in increasing measure of its financial liability under the terms of its guarantee and lay the foundations for an efficiently operating home meat industry, has thus features in common with the development councils to be established under the Industrial Organisation and Development Act, 1947, as the functions listed for the New Cotton Board, the first of such councils to be established, clearly shows.

Royal Scottish Museum, Edinburgh

A NOTABLE feature of the activities of the Royal Scottish Museum during 1946 (Ann. Rep. 1946) was the record number of temporary exhibitions that were organised. These, all of topical interest and of strong public appeal, included the "Meet Scotland" Exhibition (which ran from August 1945 until March 1946), organised by the Museum itself; "Other Peoples Jobs", organised by the Ministry of Fuel and Power, and a special health exhibition in connexion with the City of Edinburgh's Health Week. This was divided into sections dealing with maternity and child welfare, tuberculosis, school medical services, water supply, etc. A unique aspect of this particular exhibition, and one which must certainly be unique in the history of the Museum, was the presence of nursery school infants, "who," in the words of the report, "performed their exercises and ablutions, played their games and demolished their meals, completely unaffected by the mass of admiring onlookers". In reference to these and the several other special exhibitions which were provided for by various outside organisations, Dr. D. A. Allan, director of the Museum, writes: "The scope and variety of the Museum's offerings are largely determined by the possibilities of outside assistance, and the record for 1946 provides food for thought regarding museum developments in the years ahead". The attendance figures for the various exhibitions shown on p. 3 of the report certainly justify this observation. Important donations to the Museum during the year included the Fyfe collection of Japanese *netsuké* (presented by Mrs. E. J. Fyfe). A full list of acquisitions appears at the end of the report.

British Bee Plants

MANY people are interested in learning the sources of the pollen and nectar collected by bees; others are more concerned with the pollination of flowers; while the bee-keeper often wants to know the most suitable plants for extending pastorage for his stocks. To all of these, to botanists and to other readers we can commend the booklet "British Bee Plants" as a storehouse of useful information. All the best bee-plants are dealt with, whether they are in the flower or vegetable garden, orchard, farm or countryside. Often useful hints are given regarding cultivation of particular plants, their uses and other details. Edited by A. F. Harwood, it is issued by the Apis Club, The Ways End, Foxton, Royston, at 3*s*.

British Social Hygiene Council: Summer School

"THE SCHOOLS AND THE LAND" is to be the theme of a summer school that the British Social Hygiene Council is organising at the Seale-Hayne Agricultural College, Newton Abbot, Devon, during July 30–August 13. The school will be concerned with the

place of agriculture in the life of the nation, with special reference to the soil, its cultivation and improvement, grassland and arable crops, livestock husbandry, the processing and distribution of farm products, and the social and economic conditions of rural life. The school should appeal particularly to all teachers of biology, and social workers and others will be able to extend their knowledge of and sympathy with the work, outlook and social conditions of the rural community.

At the evening sessions, lectures will be given by visiting speakers, each expert in his special field. Among those who have already accepted invitations to speak are the Rt. Hon. R. K. Law, Prof. A. W. Ling, Prof. T. Wallace, Prof. D. B. Johnstone-Wallace, Mr. L. J. F. Brimble, Mr. J. H. Anderson, Mr. E. Ford, Mr. G. F. Kingston, Mr. K. C. Vear and Dr. D. A. MacPherson. The resident staff will consist of Mr. A. Roebuck, Miss H. R. Chapman, Mr. W. L. Sumner, Mr. E. Lucas, Mr. L. E. Morris, Mr. R. Weatherall and Dr. M. B. Gibbons. The fee for the School is £14 14*s*. (including £1 1*s*. enrolment fee—not returnable). This covers board and tuition. Further information can be obtained from the Secretary, British Social Hygiene Council, Dept. S.J.1, Tavistock House North, Tavistock Square, London, W.C.1.

University of Leeds: Appointments

THE following appointments in the University of Leeds have been announced: Dr. J. W. Baker, formerly senior lecturer and honorary reader in organic chemistry, to the newly established readership in the mechanism of organic reactions; Dr. C. S. Whewell, lecturer in textile chemistry, to be honorary reader in textile finishing and lecturer in textile chemistry.

University of Sheffield

THE following appointments in the University of Sheffield have been announced: O. I. Butler, senior lecturer in charge of the Department of Electrical Engineering; H. J. Cowan, lecturer in civil engineering; G. Wiseman, assistant lecturer in physiology; A. G. Macgregor, research assistant in the Department of Pharmacology and Therapeutics.

Prof. Douglas Knoop, who is retiring from the chair of economics at the end of the present session, has made a gift of money to the University to endow an economics prize, to be associated with his name, to be awarded to the student whose work in economics in the final examination for the Special Degree of B.A. has shown most distinction and promise.

Colonial Service: Appointments

THE following appointments in the Colonial Service have been announced: D. D. Campbell, agricultural officer, Uganda; H. Irving, agricultural chemist, Nigeria; D. C. Todd, agricultural officer, Uganda; G. H. Pinfield, inspector of mines, Tanganyika; L. F. Edgerley, assistant conservator of forests, Mauritius; B. R. Fuller, assistant conservator of forests, Nyasaland; S. T. Hoyle, senior agricultural officer, Lilongwe Experimental Station, Nyasaland; J. Sinclair, curator of the Herbarium, Singapore; S. Gillet (senior coffee officer, Kenya), director of agriculture, Kenya; J. T. Moon (agricultural officer, Kenya), senior agricultural officer, Kenya; C. C. Parisionos (agricultural officer, Northern Rhodesia), agricultural officer, Cyprus; A. Pickles (entomologist, Trinidad), entomologist, Nigeria; F. W. Thomas (agricultural officer, Tanganyika), senior agricultural officer, Tanganyika; J. P. Edwards (conservator of forests, Malaya), deputy director of forestry, Malaya; R. O. Roberts (chemist and petrologist, Uganda), mineralogist, Nigeria; D. F. Macpherson (senior veterinary officer, Kenya), chief veterinary officer, Nyasaland; F. L. Vanderplank (research officer, Tanganyika), entomologist, West African Institute for Trypanosomiasis.

The Night Sky in April

NEW moon occurs on April 9d. 13h. 16m., U.T., and full moon on April 23d. 13h. 28m. The following conjunctions with the moon take place: April 7d. 18h., Mercury 2° N.; April 13d. 08h., Venus 1° N.; April 18d. 02h., Saturn 4° S.; April 18d. 10h., Mars 3° S.; April 27d. 18h., Jupiter 4° N.; Mercury, in superior conjunction with the sun on April 29, is too close to the sun during the month for favourable observation. Venus is an evening star, setting at 22h. 56m. and 23h. 45m. on April 1 and 30 respectively, and shines with stellar magnitude −4 approximately during the month, about one half of the illuminated portion of the disk being visible. The planet attains its greatest easterly elongation on April 15. Mars, in the constellation of Leo, can be seen throughout the greater portion of the night, setting at 4h. 25m., 3h. 23m., and 2h. 41m., at the beginning, middle and end of the month, respectively. Jupiter, in the constellation of Sagittarius, is not visible until the early morning hours, the times of rising being 1h. 25m. on April 1 and 23h. 30m. on April 30. The planet is stationary on April 15. Saturn, in the constellation of Cancer, is visible during most of the night, setting a little before Mars, and is stationary on April 17. Occultations of stars brighter than magnitude 6 are as follows: April 13d. 20h. 31m., *k* Taur. (*D*); April 26d. 00h. 16m., 19 Scor. (*R*); *D* and *R* refer to disappearance and reappearance, respectively, and the latitude of Greenwich is assumed. There will be a partial eclipse of the moon on April 23, invisible at Greenwich, but visible over a large portion of the southern hemisphere and also over the extreme western and north-western portion of North America. The Lyrid meteors can be seen during April 18–24, but moonlight will partly interfere with the observations of this shower.

Announcements

THE governing body of the Imperial College of Science and Technology has appointed Air Chief Marshal Sir Roderic Hill to be rector of the College as from October 1, in succession to Sir Richard Southwell, who has held that office since 1942.

DR. J. CYMERMAN, lecturer in organic chemistry in Charing Cross Hospital Medical School (University of London), has been appointed lecturer in organic chemistry in the University of Sydney.

THE following have been elected officers of the Royal Photographic Society: *President*, Percy W. Harris; *Vice-Presidents*, L. V. Chilton, I. D. Wratten; *Treasurer*, H. Abbott; *Ordinary Members of Council*, Gilbert Adams, J. Allan Cash, K. H. Gaseltine, R. N. Haile, Dr. P. Hansell, T. Midgley Illingworth, Dr. S. D. Jouhar, Mrs. Rosalind Maingot, R. H. Mason, H. S. Newcombe, Aleo Pearlman, Anthony Peacock, Oliver G. Pike, B. Sinkinson, A. L. M. Sowerby.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

A 16-MeV. Betatron

DURING the past few weeks, a betatron which has been under construction by the British Thomson-Houston Co., Ltd., has come into operation, and we give some preliminary account of its properties. The magnet and coil arrangement is shown in Fig. 1. The main features of the machine are:

Maximum orbit radius	20·75 cm.
Orbit space section (where $0 < n < 1$), radial	2 "
axial	3 "
Average value of the index n	0·5
Total weight	0·85 tons
Operating frequency	50 c.p.s.
Excitation	400 volts r.m.s.
	200 amp. r.m.s.
Input power	4 kW.
Peak volts per revolution at the orbit	22
Peak flux density at the orbit	2750 gauss
Electron energy at peak flux density	16·3 MeV.

The weight and kVA. are low for a betatron of this energy. This results from having a narrow orbit space and a closed central leg which leaves the annular guide-field as the only major flux in air. The accelerating and the guide fluxes are produced by two coaxial windings which lie radially on either side of the orbit. These are excited in parallel, their turns being chosen so that the accelerating flux, most of which is in the closed central leg, bears the necessary betatron relation to the guide flux. Thus the betatron is like a transformer with a loaded inner secondary winding, the core flux of which corresponds to accelerating flux, and the leakage flux of which provides the guide field. Analogous arrangements have been proposed by Kerst[1] (flux forcing) and Wideröe[2], while the General Electric Company of America has reported[3] the successful operation of such a machine. All core components are kept in contact under pressure, and we believe that this is responsible for the quietness of the machine in operation. At 400 V. excitation, the noise level is 75 phon.

Fig. 2 shows in radial section the disposition of the guide-field pole-pieces, the vacuum chamber, and, as dotted lines, the boundaries of the region of stability. The pole-pieces were designed by an electrolytic tank method which takes into account the proximity of current-carrying conductors[4]. The field fall-off

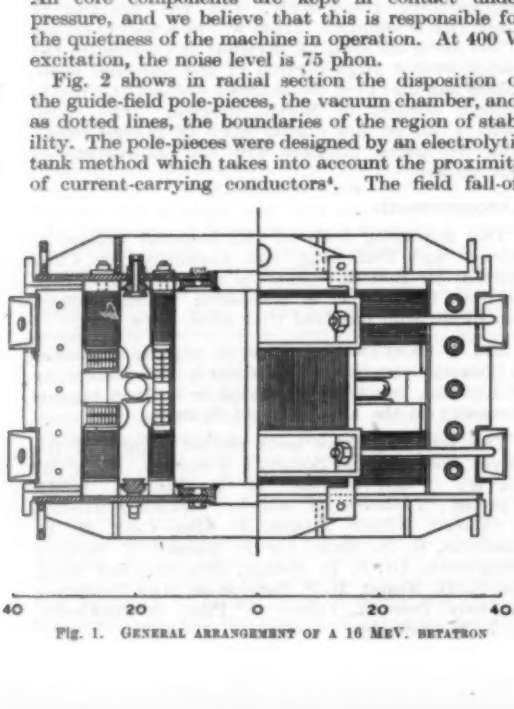

Fig. 1. GENERAL ARRANGEMENT OF A 16 MEV. BETATRON

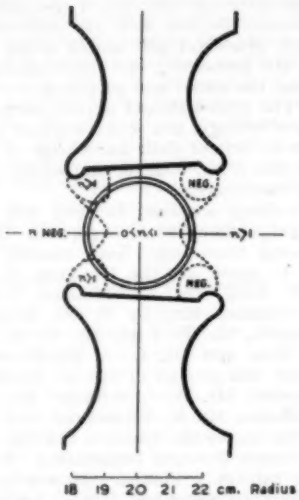

Fig. 2. GUIDE FIELD POLES, SHOWING REGIONS OF ORBIT STABILITY ($0 < n < 1$)

exponent n in $B_r = B_0 (r_0/r)^n$ was chosen to be $\frac{1}{2}$, making the radial and vertical oscillations of the same frequency and favouring an orbit space of circular cross-section. The space available for acceleration is partly blocked at one point by the gun, which at present reduces the radial width to 1·6 cm. A high degree of uniformity in the field around the orbit is called for in this machine on account of the limited orbit space, and so the pole-pieces are divided into quadrants, each capable of separate movement. By adjustment of the quadrants, variations in field around the orbit were reduced until their resultant was equivalent to an error of less than 0·3 per cent over one radian of circumference.

At the time of injection, circumferential variations in the quadrature components of the guide field are important, and, to compensate for these, coils were attached to the pole faces and fed with appropriately phased A.C. By this means the field variations at injection were reduced to the equivalent of 1 per cent (0·27 gauss) acting over one radian. Such a disturbance is estimated to produce a maximum radial oscillation amplitude of 1 cm.

Auxiliary transformers in series with one of the betatron windings supply small orbit-control voltages. An in-phase voltage controls the equilibrium orbit radius by changing the ratio between the accelerating flux and the guide flux, and a quadrature voltage serves to vary this radius during the acceleration. Due to winding resistances, there is a phase difference between the two fluxes of 0·04 radian acting in such a sense that the orbit tends to expand. This phase difference can be reduced by adjustment of the quadrature voltage; or, alternatively, the orbit radius can be allowed to drift into the target at any stage of the acceleration without using the orbit expansion pulse.

In the preliminary tests, 5 microsec. pulses were injected at 25 kV. in the orbit plane; and an output of about 0·1 r./hr. was measured at 1 metre, using an ionization chamber screened with 3 mm. of lead. Adjustments of injection voltage and timing, of orbit position, and the phase control of orbit position, were found to have the effects generally expected.

On the other hand, the gun filament current showed distinct optimum settings, above which the output decreased rapidly, suggesting that space charge may play some part in the acceptance process. The appearance at times of two stationary Geiger kicks among the random ones observed during the acceleration suggests that the orbits have a complex structure as reported for the synchrotron[5], or that some electrons, drifting to the wall, can survive and continue to be accelerated.

This acceptance and acceleration of electrons in so limited an orbit space may encourage designers to consider narrower guide-fields, more especially in very large machines.

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Feb. 24.

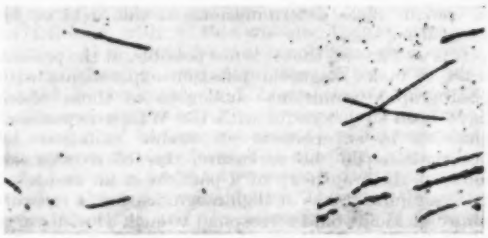
[1] Kerst, *Phys. Rev.*, **60**, 233 (1945).
[2] Wideröe, "Verlaüfige Berechnung der 200 MV. transformators", a manuscript dated March 5, 1944, referred to in B.I.O.S. Report 148, p. 4.
[3] Westendorp, *Phys. Rev.*, **71**, 271 (1947).
[4] Peierls, *Nature*, **158**, 831 (1946).
[5] Elder, Gurewitsch, Langmuir and Pollock, *J. Appl. Phys.*, **18**, 810 1947).

Applications of the Reflecting Microscope to the Nuclear Plates Technique

We have found it instructive to reverse the normal microscope procedure in the examination of nuclear emulsions; invert the plate, feed light in through the cover slip, and observe through the backing plate. With high magnification, normal objectives and ordinary glass-backed gelatine, this is not possible; but it may be done by using a reflecting microscope[1]. In this way, with oil immersion, we observed several multiple stars, and found heavy fragments which were not visible by the normal mode of examination because they were obscured by the central body of the star. In some doubtful cases, this mode of examination proved decisive in the interpretation of the event.

It was but a step to sandwich two plates, with immersion oil or Canada balsam between them (emulsion inwards), and verify that we could observe right through both emulsions with unimpaired image quality. A plate, soaked in thorium nitrate, was dried and placed against an uncontaminated plate for three days. After separation, the plates were processed in the normal way, realigned by an X-ray marking grid, and the sandwich reconstituted. The accompanying microphotograph shows two tracks which originate from a star in one emulsion and end in the other.

Since this experiment was performed, the examination of sandwiches exposed at the Pic du Midi has proved that with a normal microscope it is comparatively easy to follow the passage of particles from one plate to another with separate examination of the two plates, but only if the density of events is low. Although in our case the density of stars in the soaked plate was rather high, of the order of 20 per sq. mm., we have been able to identify the mother star of every alpha particle investigated in the second plate. These conditions provided such a stringent test of the applicability of the method in the photographic technique that we feel confident some applications, such as the dosage of radioactive substances, biological research with the auto-radiographic technique, and the measurement of long-range particles emitted by elements embedded in one of the two plates, are feasible.



The accompanying photograph shows that intimate contact between the plates was not obtained but that an air gap existed, mainly due to the large size of the plates used. With a known gap and known pressure of the gas, the 'magnification' of range thus obtained can be used for extending the field of application of the photographic plate. For example, the absorption of particles in the gas can be measured and the sign and mass of light charged particles determined by magnetic deflexion. Such an experiment is being carried out by Dr. C. F. Powell and Dr. S. Rosenblum (see following communication).

The long working distance of the reflecting microscope, which is proving useful in biological fields, will permit the examination in depth of emulsions so thick as to be beyond the range of ordinary objectives.

In the new nuclear plates the emulsion shrinkage on processing is of the order of 50 per cent, as compared with 15 per cent for the old half-tone plates, and the grain size is becoming smaller. Observation of such plates can be facilitated by using ultra-violet instead of visible light, a technique for which this instrument, being focally achromatic, is well suited.

We wish to express our gratitude to Dr. Burch for the use of the microscope, and to Dr. Burch and Dr. Powell for helpful discussion.

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G. P. S. Occhialini

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[1] Burch, C. R., *Proc. Phys. Soc.*, **59**, 41 (1947).

A New Method for the Determination of the Mass of Mesons

We have recently installed at the Jungfraujoch High-Altitude Research Station an apparatus for the determination of the masses, and the signs of the electric charge, of the various types of mesons observed in photographic emulsions exposed to the cosmic radiation. In view of the importance of obtaining reliable information on this subject, and of the desirability that similar experiments should be made by other investigators, we present a brief account of the main features of the method. In doing so, we also have in mind the possibility that charged mesons may be generated artificially in the near future by means of the large synchrotrons and synchrocyclotrons now approaching completion in the United States; and that our methods may be

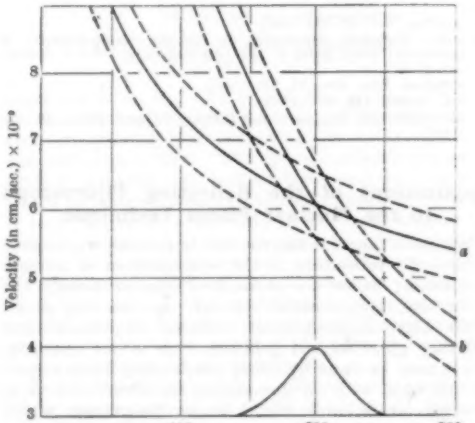
of use for mass determinations in this field of investigation also.

It is well known that it is not possible, at the present time, to make magnetic deflexion experiments with photographic emulsions—analogous to those which have been so successful with the Wilson expansion-chamber in experiments on cosmic radiation—by observations on the curvature, due to a magnetic field, of the trajectory of a particle in an emulsion. In examining tracks at high magnification, a measurable deflexion would correspond to such a small value of the radius of curvature that a field of the order of 10^6 gauss would be required; a field which, for work with cosmic-ray particles, it would be necessary to maintain over long periods of time. In addition, small-angle Coulomb scattering would greatly complicate the interpretation of the results. In these circumstances, we have chosen to make observations on the change in direction suffered by a particle in its passage through a gas, or a vacuum, in a magnetic field. For this purpose we have considered a number of possible geometrical dispositions of the photographic plates relative to the field; the following appears to be the most appropriate for the present experiments.

It has been observed by Bates and Occhialini that it is possible to detect and identify the tracks of single particles in two separate plates placed with their emulsions face to face[1]. A particle, moving with sufficient energy in a suitable direction, and originating in one emulsion, can leave the surface and cross the narrow air-gap to enter the second emulsion. The two component parts of the track of the same particle can be identified under the microscope. We therefore arrange two plates, in a suitable plate-holder, with their emulsions face to face, and separated by a distance of 3 mm. This assembly is placed between the pole-pieces of a permanent magnet giving a field of 8,600 gauss, so that the planes of the emulsions are normal to the magnetic field. A meson which enters the emulsion of one of the plates will, in general, have emerged from the emulsion of the other; and, in the space between the plates, it will have moved in a spiral path. If we can identify the track of the same particle in the two emulsions, then the observed change in the direction of motion in traversing the air gap, and the distance between the points of exit and entry of the particle in the emulsions, allows us to calculate $H\rho$ for the particle; the magnitude of its momentum in the plane perpendicular to the field is thus determined. Further, if the particle comes to rest in the emulsion, its observed range gives a measure of its velocity as a function of its mass. The two observations taken together define the mass of the particle.

For the successful application of this method, it is clearly necessary to define the geometrical relationship of the two plates during the exposure. For this purpose we expose the plates in their holder, before development, to a fine pencil of X-rays, and produce a succession of corresponding points, on the two plates, in the form of a geometrical grid. The relative positions and orientations of the two portions of the trajectory of a single particle, relative to the common grid, can thus be determined. The identification of the two portions of the trajectory of a particle is facilitated—and the probability of attributing two unrelated tracks to the same particle is greatly reduced—by the fact that the angles of 'dip' of the trajectory at the two surfaces must be equal; and that, for a given distance between the points of exit and entry of a single particle at the two surfaces, there is a relationship between the directions of motion at the two points. If we observe the direction of the projection of the trajectory, on a plane parallel to the surface of the emulsion, at the point of entry into one emulsion, the corresponding direction at a given point of exit in the other is determined.

In making observations, we first search one of the plates until we find the track of a meson which enters the surface; which stops in the emulsion after traversing a distance between 100 μ and 400 μ; and which has an angle of dip, β, on entering the emulsion, of less than 15°. From the observed angle of dip, we can determine the approximate position of the point of exit of the particle from the other emulsion, assuming an approximate value for its mass and that (*a*) it is positively and (*b*) negatively charged. We then search the regions of the second plate in the areas thus located, until we find a track which has the characteristics of a meson of the correct energy, and which emerges in the necessary direction.



To estimate the precision which we can expect to obtain with the method, we consider the analysis of an event in which a meson has a range of 200 μ in one emulsion; a value of $H\rho$ of 70,000 gauss-cm.; and an angle of dip of 10°. The observed range allows us to draw a curve (*a*) (see graph), showing the relation between the mass and velocity. Owing to straggling, this line must be replaced by a band, as shown. Similarly, the value of $H\rho$ defines the momentum of the particle, which allows us to construct curve (*b*). Here again, the line must be replaced by a band corresponding to an uncertainty in the determination of the change in the direction of the particle in passing between the plates, which we estimate to be $\pm$ 1°. The mass of the particle is determined within the limits corresponding to the region of overlap of the two bands, and a detailed analysis indicates that, in favourable circumstances, the 'probable error' in the determination of the mass of an individual particle will be less than 10 per cent. This result suggests that the method should be capable of a precision not inferior to that achieved in the best applications of the Wilson chamber.

It has previously been pointed out by Lattes, Occhialini and one of us that the failure to observe

π-mesons, and the process of μ-decay, in an expansion chamber may be associated with the very short half-value period, τ_π, of these particles. For the successful determination of the mass of these particles by the present method, it is necessary that τ_π should exceed about 3×10^{-10} sec.

For other experiments, it is possible that a different disposition of the plates and the field would prove more suitable; but the arrangement we have employed has the advantage that the determinations of the mass do not depend critically on a knowledge of the shrinkage of the emulsion; and that, apart from losses at the edges of the plates, the track of every meson entering the surface of one emulsion must have emerged from the other.

We are greatly indebted to Prof. von Muralt, Mr. H. Widerkehr and Mr. Saige for much kindness and assistance in the establishment of the apparatus at this Station.

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S. Rosenblum

Hochalpine Forschungstation,
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Jan. 6.

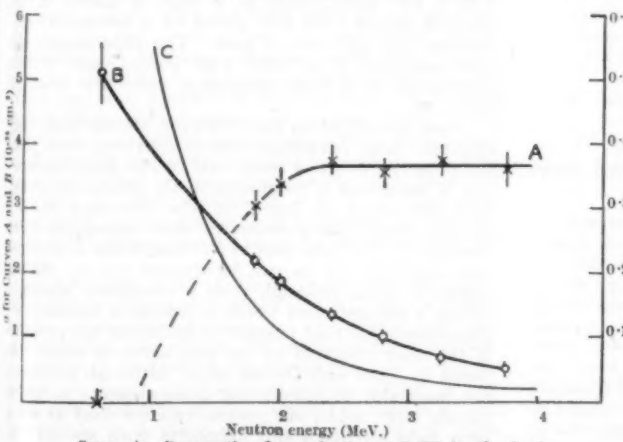
Interaction of Fast Neutrons with Indium

Indium has two stable isotopes, In^{115} (95·5 per cent) and In^{113} (4·5 per cent). In^{115} can be excited by an (n,n) process to a metastable-level (In^{115*}) at 340 keV. and returns to the ground-state by a strongly internally converted γ-transition with a half-life of 4½ hours[1]. Fast neutrons may also be captured in In^{115}, leading to two isomeric activities of In^{116} with periods of 54 min. and 13 sec. Both these processes may be regarded as competing in the initially highly excited compound nucleus In^{116}, and it was considered of interest to examine the absolute magnitude of the respective cross-sections as a function of neutron energy.

Indium foils were irradiated with fast neutrons from the C—D and D—D reactions produced by the Cavendish 1 MeV. high-tension set. The absolute flux of fast neutrons during irradiation was measured with a recoil ionization chamber filled with hydrogen and argon[2]. The decay of the indium after irradiation was followed with a thin-window Geiger counter, and the 4½-hr. and 54-min. activities were easily separable. During irradiation, the indium was surrounded by cadmium and boron to minimize the 54-min. activity produced by slow scattered neutrons. The remaining background activity was determined from inverse square plots. The absolute efficiencies of the β-counter for the two activities were determined by observing coincidences between the conversion electrons and the accompanying *K* X-rays in the 4½-hr. decay, and between the β-particles and the succeeding γ-rays in the 54-min. activity.

Although there is some evidence for irregularities in the variation of inelastic scattering cross-sections with energy[3], curve *A*, showing the cross-section for the (n,n) process leading to In^{115*}, is smooth and flat above 2·2 MeV. The curve also indicates that a threshold for this reaction probably exists in the neighbourhood of 1 MeV. If we assume from the theory of Weisskopf and Ewing[4] that the inelastic scattering cross-section above 1 MeV. is $\sim \pi r^2$ (r is nuclear radius), that is, $\sim 2 \times 10^{-24}$ cm.² for indium, then the graph shows that for primary neutrons between 2 and 4 MeV., about 20 per cent of the transitions from the excited levels in which In^{115} is left immediately after inelastic scattering lead to the metastable state. The value $\sigma = 3{\cdot}6 \times 10^{-25}$ cm.² between 2 and 4 MeV. may be compared with the rough value $\sigma = 3 \times 10^{-25}$ cm.² obtained by Reddeman for the excitation of the metastable-level Sr^{87*} with 2·5 MeV. neutrons[5,6]; both In^{115} and Sr^{87} have a spin 9/2 in the ground-state, and the metastable-level of Sr^{87*} is at 370 keV. above the ground-state.

Curve *B* shows the variation of the cross-section for the production of the 54-min. activity with neutron energy, and curve *C* the capture cross-sections deduced by Weisskopf and Ewing[4] for the neighbouring element tin, on the basis of the Bohr model of the compound nucleus. The general shapes of the curves between 2 and 4 MeV. are in fair agreement; but absolute values are widely divergent, by a factor of at least 20 (this is a lower limit as attention in this work was confined to the 54-min. capture activity) near 4 MeV.



Curve *A*: Cross-section for production of In^{115*} by the (n,n) process as a function of neutron energy.
Curve *B*: Experimental results for the cross-section for apture in In^{115} leading to the 54-min. activity of In^{116}.
Curve *C*: Theoretical results of Weisskopf and Ewing for neutron capture in tin

In^{113} has very similar nuclear properties to In^{115}. It has a metastable state at 380 keV. with a half-life of 104 min. During this investigation, the excitation of In^{113*} by an (n,n) process has been detected by following the decay of the *K* X-rays accompanying conversion electrons of the isomeric transitions with a krypton-filled counter. Electrons were stopped by a layer of polythene which transmitted the X-rays, and these were distinguished from γ-rays by their strong absorption in a thin molybdenum foil; the 54-min. capture period which would conceal the 104-min. period of In^{113*} was thus eliminated. The cross-sections for the excitation of In^{113*} and In^{115*} by the (n,n) process with D—D neutrons were found to be of the same order of magnitude, just as in the case of direct excitation with X-rays[7]. The similarity in the properties of the low metastable levels of the

two stable indium isotopes is analogous to the behaviour of the metastable levels[8] of the two stable odd silver isotopes $Ag^{107,109}$.

A fuller account will be published later.

I am indebted to Mr. D. West for initial discussions which led to these experiments, to Mr. K. W. Allen for his advice in the neutron flux measurements, and to Prof. M. H. L. Pryce for his comments on the results.

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Dec. 10.

[1] Goldhaber, Hill and Szilard, *Phys. Rev.*, **55**, 47 (1939).
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[3] Grahame, *Phys. Rev.*, **69**, 360 (1946). Nonaka, *Phys. Rev.*, **59**, 681 (1941).
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[6] Dubridge and Marshall, *Phys. Rev.*, **57**, 348 (1940).
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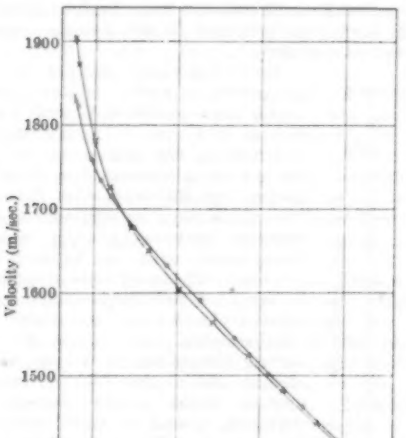
Ultrasonic Dispersion in Organic Liquids

I HAVE measured the velocity of sound, v, at frequencies between about 700 and 3,000 kc./s., and at temperatures between about + 15° and − 80° C., in the following liquids: *iso*-butyl alcohol; geraniol, $(CH_3)_2.C : CH.(CH_2)_2 . C(CH_3) : CH.CH_2OH$; di-dihydrocitronellyl ether $[(CH_3)_2 . CH . (CH_2)_3 . CH(CH_3) . (CH_2)_2]_2O$. There is evidence of negative dispersion ($\partial v/\partial f < 0$) in all three liquids, and of positive dispersion ($\partial v/\partial f > 0$) in geraniol and di-dihydrocitronellyl ether near the lower end of the temperature-range. The negative dispersion in *iso*-butyl alcohol is very small and near the limit of experimental error, but it is more pronounced in the other two liquids.



VELOCITY OF SOUND IN DI-DIHYDROCITRONELLYL ETHER AS A FUNCTION OF THE TEMPERATURE AT 689 kc./s. (○) AND AT 2102 kc./s. (×)

The accompanying graph, which refers to di-dihydrocitronellyl ether, is an example of the ultrasonic behaviour of these compounds. It will be seen that the onset of positive dispersion is marked by a more rapid increase of the velocity of sound with falling temperature than at higher temperatures.

A full account of this work will be published elsewhere.

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Magnetic Susceptibility of Mica

THE magnetic susceptibilities of various natural micas have been measured by Wilson[1] and Nilakantan[2]; the latter also measuring the anisotropy. It was found that for micas which are substantially free from inclusions of magnetite, and in which the iron is therefore present in the crystal lattice, the paramagnetic susceptibility is proportional to the iron content. It was therefore surprising that Eitel and Dietzel[3] should report that synthetic mica containing only 0·05 per cent of iron is still paramagnetic, since a small cleavage flake orientated itself parallel to the magnetic field. A rough calculation shows that a mineral corresponding to their synthetic fluorphlogopite ($KMg_3AlSi_3O_{10}F_2$) should have a specific diamagnetic susceptibility of $-0{\cdot}35 \times 10^{-6}$ c.g.s. units, and using the usual Bohr magneton value for iron of $P_B = 5$ and calculating the paramagnetic susceptibility of iron from the relation $P_B = 2{\cdot}84\sqrt{\psi T}$, where ψ is the susceptibility per gram-ion, one finds that 0·2 per cent of iron corresponds to a paramagnetic susceptibility of just $+0{\cdot}35 \times 10^{-6}$ c.g.s. units. A mica with a greater iron content should therefore be paramagnetic, but with less iron should be diamagnetic. Eitel and Dietzel suggested that the anomalous paramagnetism found by them was connected in some way with the highly anisotropic crystal structure of mica.

We have prepared synthetic mica[4] by the method used by Eitel and Dietzel, and a measurement of its susceptibility by the Gouy method gave a value of $1{\cdot}60 \times 10^{-6}$ c.g.s. units at a field of about 9,000 oersteds between the pole pieces for a specimen containing 0·04 per cent of iron. The paramagnetism thus appeared to be very high indeed, and would correspond to a Bohr magneton value for iron of $P_B = 25$.

Closer investigation has, however, shown that this apparent large paramagnetism is spurious, and that the observed effect is really due to the ferromagnetism of inclusions of magnetite in the synthetic mica. This conclusion is based on the following facts: (1) the susceptibility decreases with increasing field strength; (2) a large part of the iron in the synthetic mica prepared by us can be washed out by dilute sulphuric acid, although such a treatment scarcely affects a natural mica which is free from inclusions; thus confirming that magnetite inclusions are present in the mica prepared by us, and hence in that prepared by Eitel and Dietzel also. Although we have not been able to extend our measurements to sufficiently large fields, our results indicate that at very large field strengths this synthetic mica should become diamagnetic, the ferromagnetic inclusions then being saturated and the intrinsic diamagnetism of the mica causing a cleavage flake to set perpendicular to the field.

We carried out similar experiments with a sample of the synthetic fluorphlogopite prepared by Middel[5] and found that in this case magnetite inclusions were substantially absent, although the iron content was about the same (0·05 per cent), since the mineral was diamagnetic at all fields. This is no doubt due to the very much slower cooling rates used by Middel during the crystallization of the mica. (He prepared melts of up to 100 kgm., while Eitel and Dietzel and ourselves prepared melts of only about 200 gm.) The specific susceptibility of Middel's synthetic mica was measured by us, using the Rabi method. Different values for the specific susceptibility parallel to the cleavage plane were obtained for different crystals, ranging from $-0{\cdot}17 \times 10^{-6}$ to $-0{\cdot}29 \times 10^{-6}$ c.g.s. units. This variation would indicate that the small iron content is unevenly distributed throughout the mica crystal lattice.

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[1] Wilson, E., *Proc. Roy. Soc.*, A, **96**, 429 (1920).
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[3] Eitel, W., and Dietzel, A., Appendix to B.I.O.S. Report 785 (1946).
[4] Kendall, J. T., and Spraggon, W., paper read at XIth International Chemical Congress, London (1947).
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A Large Field Compensator for Measurement of Birefringence

In the measurement of stresses in glass using polarized light, it is usual to employ some form of compensator in which the amount of birefringence varies uniformly across the field of view and passes through zero value at the centre. This gives a series of parallel fringes when viewed suitably between crossed polarizer and analyser. With white light the central fringe is black, and serves as a useful index.

In the Babinet compensator the uniform variation of birefringence is obtained by superimposing two narrow-angle quartz wedges, cut with their optic axes at right angles, with the thick edge of one adjacent to the thin end of the other. The same effect can be obtained by uniformly bending strips of a photo-elastic material in a plane perpendicular to the direction from which it is to be viewed. The central black fringe corresponds to the neutral plane of the bent beam so formed, and fringes due to tension and compression are seen on either side of it. A compensator based on this principle has been described by Holmes[1] and consists of a strip of plate-glass uniformly bent in a suitable bending device, with the plane of bending parallel to the polished faces of the glass.

It has been found possible to produce the same effect by bending a strip of the resin *CR*. 39 in a similar way. The strain pattern can be 'frozen' into this material and the bending device afterwards discarded. A clamp is used which, by means of a screw, can be made to apply equal and opposite couples to the two ends of a strip of the material, so that it is bent uniformly in a plane parallel to the original faces of the sheet from which it was cut. The clamp holding the strip loosely in an unstrained condition is placed in an oven maintained at 105° C. After about ten minutes the sample is removed from the oven and the screw quickly tightened to give the desired strain pattern in the strip. After cooling to room temperature and removal from the clamp, the strip retains the strain pattern, which does not alter appreciably after the first 24 hours. Most of the unwanted end portions where the couples were applied, and where the bending is not uniform, may then be sawn off without affecting the system of parallel fringes extending over the remainder of the strip.

Strips 14 in. × 2 in. of various thicknesses have been used; but the dimensions are limited only by the sizes of clamp and oven available. With this size, parallel fringes cover an area of approximately 8 in. × 2 in., and up to three fringes on either side of the neutral fringe have been obtained in a thickness of ¼ in. A limit is set to this number by the flexural strength of the material when hot. The curvature of the strip with this amount of strain is apparent, but for most applications is not objectionable. By using a number of strips built up into a single unit the number of fringes may be increased; or alternatively the amount of curvature for the same number of fringes may be decreased.

Two strips of 'Polaroid' with their planes of polarization suitably orientated may be used as polarizer and analyser with the compensator. This combination forms a direct vision strain-viewer with a large field of view which may be used with any bright background and needs no projection system. One of the strips of 'Polaroid' may conveniently be mounted on one surface of the compensator and the other in a suitable holder, so that the whole apparatus comprises two compact units. Since no setting up is required, the compensator used in this way is useful for the rapid examination of stresses in glass both under laboratory and also under factory conditions.

The compensator described is superior to the quartz type as regards size of field, and may be of some interest for the evaluation of the degree of birefringence in problems other than the special application in this laboratory.

The work on this compensator was carried out in the Research Laboratory of Messrs. Pilkington Brothers, Ltd., who have kindly agreed to publication.

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Dec. 16.

[1] *J. Sci. Instr.*, **17**, 227 (1940).

New Bands in the Schumann–Runge System of the Oxygen Molecule

Oxygen produced by heating potassium permanganate crystals was excited by a high-frequency (750–850 kc./sec.) discharge (output power less than 10 watts) and the spectra protographed both in the visible and in the ultra-violet regions by a Fuess glass prism spectrograph and a small (baby) quartz prism spectrograph respectively. A good many of the more intense bands of the Schumann – Runge system were found on both our plates. On attempting to extend the system, we discovered that a number of new bands present on our plates, but not reported by previous workers, fitted in the $(v'v'')$ scheme of this system. These new bands (ν_{vac}) along with our proposed quantum assignments are given in the accompanying table.

S.N.	ν_{vac}	Proposed (v',v'')	S.N.	ν_{vac}	Proposed (v',v'')
1	22277	(8,25)	14	28212	(7,19)
2	22616	(0,20)	15	29824	(4,16)
3	22804	(9,25)	16	30361	(1,14)
4	23208	(6,23)	17	30416	(3,15)
5	23270	(8,24)	18	31005	(2,14)
6	24120	(4,21)	19	31056	(4,15)
7	24244	(6,22)	20	31625	(1,13)
8	24285	(8,23)	21	32252	(6,15)
9	24605	(3,20)	22	32291	(2,13)
10	26452	(4,19)	23	35828	(8,13)
11	27065	(5,19)	24	36575	(7,12)
12	27368	(2,17)	25	37327	(6,11)
13	28005	(3,17)	26	40776	(5,8)

These bands are very strongly degraded to the red. The distance between the head and the origin of a band of this system is found to be less than 0·5 A. This gives to most of the bands of this system a confused line-like structure with instruments of small dispersion such as have been used in the present case. However, their existence as bands is definite on our plates.

The quantum assignment of these new bands gives vibrational differences (both in the initial and in the final states) of the expected magnitudes. It is, however, to be noted that appreciable discrepancies in the initial vibrational differences for the level (2–3) and in the final vibrational differences for the levels (12–13) and (13–14) appear on account of too low (λ) values of the bands (3,17) and (0,14) (as obtained by us in the present case).

Since the Schumann – Runge system is in general difficult to observe in emission by other methods of excitation, it appears that the high-frequency discharge is especially suited for obtaining this system in emission. Its appearance here is due to the selective excitation property of the latter.

In conclusion, it may be mentioned that Flory[1] thinks that the $^3\Sigma_u^-$ state predissociates before the bands with $v' > 2$ can be obtained in emission. But he gives no rigorous proof for such a predissociation. The existence on our plates of the new bands with $v' > 2$ (most of which have been marked on the enlargements of the spectrograms and will be published along with the details), however, is quite certain. If theoretical conclusions, based on the present accepted structure of the oxygen molecule, question the existence of these new bands of the Schumann – Runge system in emission, reconsideration is necessary of the structure of the oxygen molecule (a conclusion we have arrived at from many other points of view also).

I wish to thank Prof. R. K. Asundi, of the Benares Hindu University, under whose guidance the work has been done.

LALJI LAL

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Nov. 27.

[1] Flory, Paul J., *J. Chem. Phys.*, **4**, Nos. 1–12, 23 (1936).

Meteor Whistles

MANY observers have reported Doppler-effect heterodynes in the background of received high-frequency broadcast signals. The accepted explanation of the whistles is that waves received after reflexion from ionized meteor trails have undergone a frequency-shift, relative to the waves received by a more direct path. Usually, the pitch of the heterodyne descends to zero. Chamanlal and Venkataraman[1] suggested, in 1941, that the descending pitch was the result of the meteor being rapidly retarded in velocity. More recently, Sir Edward Appleton and Mr. R. Naismith[2] proposed an alternative explanation of the change of pitch, which is ascribed to the reduction of the difference between the two path-lengths that occurs as the meteor, travelling tangentially to the observer, approaches the minimum distance.

The latter explanation, involving only the changes in geometry of the reflected ray, is more acceptable because it does not fail to account for the less frequent observations in which the pitch of the heterodyne first descends, passes through zero and then rises again. We have observed these 'doublet' whistles on numerous occasions, although they occur only 1 or 2 per cent as frequently as the single whistles with a falling note. We believe that the dual whistles are caused by meteors that do not approach the earth directly but pass through the atmosphere sufficiently near to earth to ionize a track and to reflect radio signals. The relative velocity of the meteor to earth may, in these cases, be sufficient for the meteor to avoid being deflected and 'captured'.

We used the word 'tadpole' to describe meteor whistles when they were first noted here some years before the War. Unfortunately, the significance of the heterodynes and their connexion with meteoric ionization was only guessed and could not be proved until after short-wave cathode-ray direction-finding apparatus became available to us in 1940, and it was possible to make simultaneous observations of radio direction and of the direction of visible meteor trails in the night sky. By this time, other observers had published conclusions similar to ours.

Since that date, we have made numerous recordings of the phenomena, and it may be of interest to note the results of our observations, as follows:

(1) At the moment when the whistle reaches zero pitch, there is a large increase in the strength of the received signal, as stated by other observers. Amplitude changes of at least 20 to 1 have been recorded here, on carrier frequencies between 15 and 22 Mc./s.

(2) Whistle durations of up to 7 sec. have been followed by 'bursts' of high-amplitude reception sometimes lasting for 10 sec. and, more rarely, for so long as 40 sec.

(3) Of the total of audible whistles, only 1 or 2 per cent have been 'doublets', as noted above. Others have all been falling in pitch.

(4) Whistles have been most commonly heard at the times of year which correspond with the arrival dates of known meteor streams. They are very seldom audible during day-time. The minimum observations occur in the period between about two hours after sunrise and two hours after sunset. Following this, they become audible in increasing numbers, with a maximum about the time of sunrise, falling off rapidly thereafter.

(5) Correlation between visible meteor trains and direction-finder bearings of falling-note radio whistles can often be obtained. We have not yet succeeded in correlating the doublet whistles in this way, perhaps because the visible meteor trails would be too near the horizon of the observer.

(6) It would appear that conditions for reflexion usually fail when the radio whistle reaches a pitch of about 2 kc./s. The whistle heterodyne seldom reaches a higher frequency than this, either when falling or rising.

(7) Amplitude 'bursts'—but without previous heterodyne whistles—have been noted on amateur radio transmissions at frequencies of 60 Mc./s. The bursts on this higher frequency appear to be of shorter duration, possibly with greater amplitude change, than those experienced in the lower frequency bands. Although difficult to record on account of the short duration, the increase in signal-level seems often to reach 35 db. (that is, 56 : 1 ratio).

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Dec. 12.

[1] Chamanlal and Venkataraman, *Nature*, **149**, 416 (1942); summary of article in *Electrotechnics* (Bangalore, Nov. 1941).
[2] Appleton, Sir Edward, and Naismith, R., *Proc. Phys. Soc.*, **59**, 461 (1947).

Open-Hearth Furnace Models

Large-scale trials recently carried out on open-hearth furnaces[1] emphasize the need for more fundamental knowledge of the flow of fuel, air and combustion products through the furnace chamber. To obtain such information by experimental work on a production furnace presents extreme difficulties due to the high working temperature and the necessity of avoiding interference with production. The problem of flow through such complex ducts having also proved too difficult to solve mathematically, it was decided to use a model technique. Models of open-hearth furnaces with differing port designs were therefore made in 'Perspex' on a 1/24 linear scale.

Both fuel gas and air are represented in the model by water. The two flows ('air' and 'gas') to the model are separately metered and can be controlled so that the Reynolds numbers at the incoming ports are equal to the corresponding Reynolds numbers on the actual furnace. The partition of 'waste gases' between outgoing gas and air ports can be similarly controlled by adjusting valves. Flow through the model has been studied in three dimensions using a variety of methods. At present use is made of fine aluminium particles suspended in the water, and illuminated in any desired direction by means of an intense sheet of light. By suitably compounding the two-dimensional patterns thus obtained, a three-dimensional pattern of flow throughout the furnace can be built up. The patterns are recorded photographically, the light source being either (*a*) an overrun 2 kW. line filament lamp; or (*b*) a specially designed Mullard discharge tube, the duration of flash from which is adjustable.

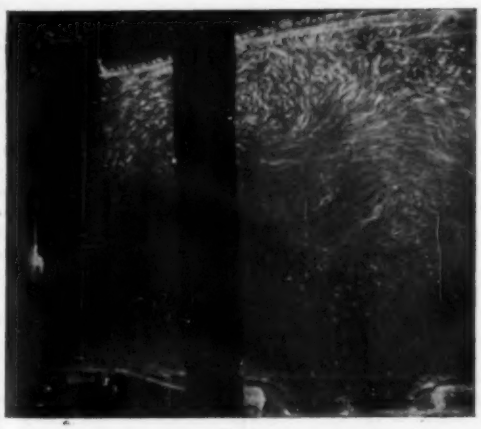

Fig. 1

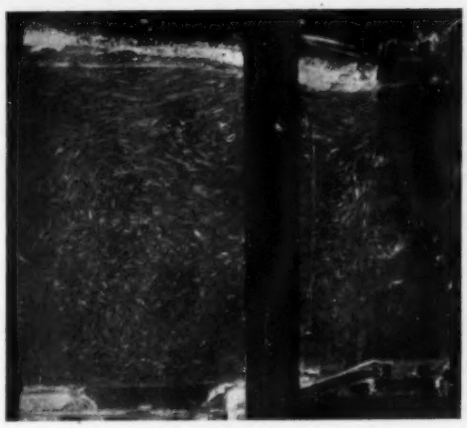

Fig. 2

The work is still at an early stage; but preliminary conclusions with a model of a Maerz open-hearth furnace show:

(1) At the incoming end of the furnace a major vortex is produced on either side of the incoming gas stream over a wide range of flow (Fig. 1). The vortices are asymmetrical and are actually three-dimensional in character.

(2) In the centre of the furnace there is a region of instability in which the particles are moving in all directions.

(3) Near the outgoing end of the furnace, the flow tends to align itself before entering the outgoing ports (Fig. 2) and is particularly rapid along the back-wall.

The general eccentricity of flow is also apparent from a study of the photographs. In particular, Fig. 1 shows that the incoming gas stream is deflected towards the furnace back-wall, although the centre-line of the gas ports is parallel to the centre-line of the furnace. This is of practical interest as it is normal for the line of the gas port on a furnace to be inclined towards the front-wall at an angle of about 3° to the centre-line, in order to counteract the tendency for the flame to be diverted towards the back-wall. The need for this correction has generally been ascribed to air inleakage through the doors, whereas it would appear to be desirable purely because of the asymmetrical furnace design.

It is of interest to note that a somewhat similar flow pattern has been found in the flame tubes of jet engines[2].

A report giving detailed results of the present work will be published elsewhere.

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[1] Iron and Steel Institute Special Report No. 37.
[2] *J. Inst. Fuel*, **21**, No. 116, 1 (1947).

Effect of Ionic Charges on the Energy and Entropy of Activation of Heterolytic Reactions

A PREVIOUS investigation[1] of the influence of the carboxylate-ion substituent on the kinetics of solvolysis of organic bromides, *R*Br, showed that in the two series (*R* =)

CH_3	$CH_2(CO_2^-)$	$CH(CO_2^-)_2$	(1)
CH_2Me	$CHMe(CO_2^-)$	$CMe(CO_2^-)_2$	(2)

there is (where indicated) a change of mechanism from S_N2 to S_N1 as the CO_2^--groups accumulate. We have now investigated the kinetics of the solvolysis of the bromides of two more series (*R* =),

Me_2C	$Me_2C(CO_2^-)$	$MeC(CO_2^-)_2$	(3)
t-$BuCH_2$	*t*-$BuCH(CO_2^-)$	*t*-$BuC(CO_2^-)_2$	(4)

and the results permit consideration of the further series (*R* =)

$$HC(CO_2^-)_2 \quad MeC(CO_2^-)_2 \quad t\text{-}BuC(CO_2^-)_2. \qquad (5)$$

Throughout series (3), (4) and (5), mechanism S_N1 prevails; and the main interest of the new results relates to the effect of the carboxylate-ion substituent on the unimolecular rate-constants k_1, and on their parameters *E* and *B* in the Arrhenius equation $k_1 = B \exp - E/RT$. The measured reaction is in all cases the heterolysis (ionization) of the CBr-bond. The data are in the accompanying table.

RATE CONSTANTS AND ARRHENIUS PARAMETERS FOR THE UNIMOLECULAR SOLVOLYSIS OF BROMIDES

Series	Solvent	*R* in *R*Br	k_1 (25°) (sec.$^{-1}$)	*E* (kcal.)	*B* (sec.$^{-1}$)
3	"60%" EtOH—H_2O	[3]Me_2C	$3{\cdot}8\times10^{-6}$	21·7	$3{\cdot}4\times10^{13}$
		$Me_2C(CO_2^-)$	$5{\cdot}6\times10^{-8}$	27·8	$1{\cdot}6\times10^{16}$
		$MeC(CO_2^-)_2$	$1{\cdot}6\times10^{-6}$	28·0	$6{\cdot}5\times10^{16}$
	H_2O	$Me_2C(CO_2^-)$	$1{\cdot}2\times10^{-4}$	29·2	$3{\cdot}8\times10^{17}$
		[3]$MeC(CO_2^-)_2$	$8{\cdot}7\times10^{-6}$	30·3	$1{\cdot}6\times10^{17}$
4	"50%" EtOH—H_2O	[4]-$BuCH_2$	$8{\cdot}0\times10^{-11}$	29·1	$1{\cdot}8\times10^{13}$
		t-$BuCH(CO_2^-)$	$1{\cdot}1\times10^{-7}$	32·9	$1{\cdot}5\times10^{17}$
		t-$BuC(CO_2^-)_2$	$2{\cdot}5\times10^{-4}$	26·4	$5{\cdot}4\times10^{15}$
	H_2O	*t*-$BuCH(CO_2^-)$	$1{\cdot}7\times10^{-7}$	32·3	$6{\cdot}6\times10^{16}$
		t-$BuC(CO_2^-)_2$	$7{\cdot}3\times10^{-6}$	28·8	$9{\cdot}7\times10^{16}$
3	H_2O	[3]$HC(CO_2^-)_2$	$3{\cdot}4\times10^{-6}$	32·5	$2{\cdot}5\times10^{16}$
		[3]$MeC(CO_2^-)_2$	$8{\cdot}7\times10^{-6}$	30·3	$1{\cdot}6\times10^{17}$
		t-$BuC(CO_2^-)_2$	$7{\cdot}3\times10^{-6}$	28·8	$9{\cdot}7\times10^{16}$

We shall require one further set of figures, namely, the following approximate values for a secondary alkyl bromide: k_1 (25°) = 10^{-7} sec.$^{-1}$, *E* = 26 kcal., *B* = 10^{13} sec.$^{-1}$; they are deduced by interpolation, since no direct determination is yet available[4], though consistent figures for the secondary chloride, *t*-BuCHMeCl, have recently been obtained by Mr. R. J. L. Martin. The following statements can be made: (i) A replacement of H by Alk at the seat of substitution of an alkyl bromide increases k_1 by a factor of approximately 10^4; and a second such substitution repeats the effect. (ii) These effects on rate are mainly (that is, to the extent of about three-quarters of the logarithmic change) due to changes in *E*, each replacement of H by Alk decreasing *E* by about 4 kcal. (iii) The replacement of H by CO_2^- increases k_1 by factors of order approximately 10^3, and therefore the replacement of Alk by CO_2^- reduces k_1 by small factors of average order approximately 10^1. (iv) This small effect on rate, when it arises from a *first* replacement of Alk by CO_2^-, results from the near-cancellation of two large effects; for the replacement increases *E* by 6–8 kcal., and also increases *B* by factors 10^3–10^5. (v) The similarly small effect on rate, arising from a *second* replacement of Alk by CO_2^-, results from small effects on *E* and on *B*.

The groups Alk and CO_2^- both repel electrons. The effects (i, ii) due to Alk have previously been interpreted as being mainly of internal polar origin[4]. Quite similar effects should also originate in the group CO_2^-. However, the important qualitative difference between Alk and CO_2^- is the ionic charge on the latter; and we may now consider briefly how this might produce the special effects (iii, iv, v) which arise when we replace one group by the other.

Such effects are considered to be due to solvation. The principal differences of solvation energy should arise in the initial states of these halide ionizations, because in the initial states such charges as are present are relatively localized, whereas in the transition states the charges are distributed, with partial neutralization of any pre-existing charges. Thus the increase of 6–8 kcal. in *E*, which we observe on introducing a first CO_2^--group in place of the comparably electron-repelling group Alk, is attributable essentially to an additional solvation energy in the initial state, which is only partly compensated in the transition state.

The corresponding increase in *B* by factors 10^3–10^5 is similarly ascribed to pre-fixation of the solvent. Relatively to co-ordinate axes imbedded in a reactant molecule, certain solvent molecules must be restricted by an ionic charge in the initial state to positions which are geometrically close to those which solvating solvent molecules will be required to occupy in the transition state; and thus their displacement from one set of positions to the other will be accompanied by a smaller entropy decrease than would have been involved in the absence of the initial charge.

The large increase in *E* is not repeated on the introduction of a second CO_2^--group, because only one such group can be involved with the forming carbonium ion in the transition state, and hence the second will produce closely compensating amounts of extra solvation energy in the initial and transition states. Again, the large effect on *B* will not be repeated, because, while one CO_2^--group will guide the solvent molecules as described, the other will solvate so similarly in the initial and transition states that it can contribute little to the entropy difference.

The rates of reactions in solution are often considered on the basis that certain frequency factors (of the order of a vibration frequency for unimolecular reactions, and of a collision number for bimolecular reactions) are 'normal', so that it is chiefly the departures from such values which merit discussion. The theories which proceed on these lines, having been evolved by extension from studies of gaseous reactions, do not sufficiently make solvation a prime consideration in the determination of 'normality'. Our point of view is that solvation energy and entropy are the most characteristic determinants of reactions in solution, and that for this class of reactions no norm exists which does not take primary account of solvation. Further illustration and

discussion will be offered in papers being submitted to the Chemical Society.

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E. D. Hughes
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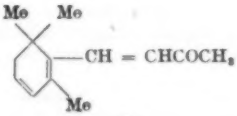
Jan. 27.

[1] Hughes and Taher, *J. Chem. Soc.*, 956 (1940).
[2] Cooper, Hughes and Ingold, *J. Chem. Soc.*, 925 (1940).
[3] Dostrovsky and Hughes, *J. Chem. Soc.*, 166 (1946).
[4] Dostrovsky, Hughes and Ingold, *J. Chem. Soc.*, 191 (1946).

Synthesis of Dehydro-β-Ionone

The elegant brominating reagent, N-bromosuccinimide, has been employed by Karrer[1] to prepare *bis*dehydrolycopene from the acyclic carotenoid, lycopene. It has now been shown that the cyclic compound β-ionone reacts in a facile manner with this reagent, giving a bromo-derivative which on dehydrobromination with diethylaniline yields dehydro-β-ionone (I), b.p. 75° at 1 mm. mercury pressure, n_D^{22} 1·5497. The absorption spectrum exhibited maxima at 2210 A. and 3380 A. (ε = 7,000 and 9,000 respectively). The product was characterized by the formation of a semicarbazone (m.p. 144–146°) and a 2 : 4-dinitrophenylhydrazone (m.p. 150–151°).



(I)

The synthetic potentialities of dehydro-β-ionone for the preparation of dehydro-compounds of the vitamin A type are now under investigation in these laboratories. The synthesis of dehydrovitamin A_1 by the above approach would be of considerable interest, since this structure is one that has been suggested[2] as representing vitamin A_2.

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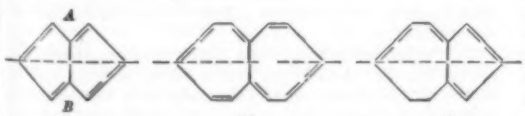
[1] Karrer, P., and Rutschmann, J., *Helv. Chim. Acta*, **28**, 793 (1945).
[2] Gray, E. LeB., and Cawley, J. D., *J. Biol. Chem.*, **134**, 397 (1940).

The Non-Benzenoid Aromatic Hydrocarbon Pentalene

It is an interesting fact that neither pentalene (1), nor heptalene (2), nor any derivatives of them have been definitely reported as being synthesized[1] or found to occur naturally. Azulene (3) is, on the other hand, a substance which can be made by the established procedures of organic chemistry and it is known in Nature.



(1) (2) (3)

When a study is made of these molecules by the valence-bond method first developed by Hückel[2], pentalene and heptalene prove to be different in one respect from azulene, and from other common hydrocarbons: the wave functions describing the most stable state of their π-electrons are antisymmetrical with respect to the axis indicated in the diagrams. In contrast, the π-electron wave functions of azulene, of all hydrocarbons built up from six-membered rings and of other common hydrocarbons, have the full molecular symmetry in their ground-states. An example of a possible exception to this statement is provided by acenaphthylene, which is being investigated. It is not obvious, however, whether this difference between the known hydrocarbons and the unknown pentalene and heptalene is connected with the difficulty of obtaining these latter structures.

In an earlier paper, Coulson and Rushbrooke[3] have examined these molecules by the molecular orbital approximation. In that method, all molecules with an even number of π-electrons are described as having symmetrical ground-states, so that the distinction of symmetry does not emerge. Coulson and Rushbrooke did, however, find that the molecular orbital method encounters a difficulty in dealing with these molecules, but the same difficulty arises with the known molecule azulene as with the other two.

Details of energies, bond orders, etc., are being reported elsewhere, especially for pentalene. According to the calculations, this molecule should possess considerable resonance stabilization (*c.* 40 kcal.), and it has been confirmed in the calculations that the triplet state lies above the lowest singlet, so that the unsymmetric state discussed above is, in fact, the lowest of all the states. A calculation of bond orders by the method of Penney[4] gives the unusual result that the central bond (*A*—*B* in formula 1) has a small negative bond order, expressing the fact that the π-electrons exert a considerable repulsion across that bond; the large resonance energy, however, confirms that the overall effect of π-electron interaction, when all the resonance possibilities are considered, is strongly stabilizing.

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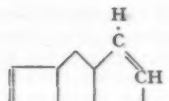
[1] Horn, Nunn and Rapson, *Nature*, **160**, 830 (1947).
[2] Hückel, *Z. Phys.*, **70**, 204 (1931).
[3] Coulson and Rushbrooke, *Proc. Camb. Phil. Soc.*, **36**, 193 (1940).
[4] Penney, *Proc. Roy. Soc.*, A, **158**, 306 (1937).

Xanthotoxin from the Fruits of *Ammi majus* L.

Fahmy and Abushady[1] have isolated from the fruits of *Ammi majus* L. a crystalline product to which they gave the name 'ammoidin'. We wish to express our gratitude to them for supplying us with this material and for allowing us to determine its constitution. We have found that the substance does not contain active hydrogen or an acetyl group[2], but it contains one methoxyl grouping. Analysis of ammoidin gave the formula $C_{12}H_8O_4$, and after degradation we found that it possesses the constitution:



This constitution is identical with that of xanthotoxin, which had been isolated by Thoms from the fruits of *Fagara xanthoxyloides*[3] and from the berries of *Luvanga scandens* by Bose and Mookerjee[4], and which had been synthesized by Späth and Pailer[5]. We have found that ammoidin possesses the same properties as those described for xanthotoxin; for example, the product, m.p. 233°, was obtained from ammoidin under the same conditions which were followed for the preparation of nitroxanthotoxin[3]. The identity of ammoidin and xanthotoxin was finally proved by the mixed melting point (no depression) with an authentic sample of xanthotoxin; this was kindly done for us by Prof. Ebert of the University of Vienna.

Pharmacological aspect. The powdered fruits of *Ammi majus* are taken by mouth by the public in Egypt to cure leukoderma; the patient exposes the leukodermic patches repeatedly to the sun for half an hour after administration of the crude drug.

Xanthotoxin (ammoidin) has been given internally to leukodermic patients or applied as a paint over the leukodermic patches, resulting in the same curative effect as shown by the crude drug but without the toxic effects of the latter[6].

Note added in proof. Fahmy and Abushady have isolated a second crystalline substance which we have shown to be imperatorin[7].

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[1] *Quart. J. Pharmacy and Pharmacology*, **20**, 281 (1947).
[2] *Nature*, **160**, 468 (1947).
[3] *Ber.*, **44**, 3325 (1911).
[4] *J. Indian Chem. Soc.*, **21**, 181 (1944).
[5] *Ber.*, **69**, 767 (1936).
[6] Private communication from Prof. I. R. Fahmy and H. Abushady.
[7] Späth and Holzen, *Ber.*, **66**, 1137 (1933).

Active Penetration of Fat into Adipose Tissue

WHEN adipose tissue of the rat, depleted of part of its fat by prolonged hunger, is incubated with blood or serum of the same rat, a decrease in the fat content of the medium can be demonstrated. Killing the tissue by heating to 80° C. abolishes this effect. The addition to the medium of sodium fluoride (*M*/20 or *M*/40), or of sodium cyanide (*M*/500) also completely inhibits the disappearance of fatty acids. Sodium azide (*M*/1,000) had no inhibiting effect. The most marked decrease in the fat content of the medium was obtained with adipose tissue and blood of rats starved to 25 per cent loss of weight. With fat-laden adipose tissue of normal rats the effect was negligible or absent. No decrease in the fat content of the blood was found when the incubation was carried out at room temperature. The accompanying table summarizes these results.

No. of expts.	Tissue	Medium	Average decrease in fat content of medium
17	Depleted groin fat	Blood of same rat	40±2·6 per cent
5	,, heated to 80° C.	,, ,, ,,	0
6	Fat-laden groin fat	,, ,, ,,	10±8 ,, ,,
4	Depleted groin fat	,, with *M*/20 NaF	0
4	,, ,, ,,	,, with *M*/40 NaF	5 ,, ,,
5	,, ,, ,,	Serum, with *M*/500 NaCN	0
3	,, ,, ,,	Blood, with *M*/1,000 NaN$_3$	34 ,, ,,
3	,, ,, ,,	Blood, at room temperature	0

100 mgm. of groin fat are cut with scissors to a fine brei and incubated with 1 ml. of blood or serum, in air, at 38° C. The fatty acid content is estimated in 0·1 ml. of the medium after half an hour (initial value) and after 3½ hours of incubation, according to the method of Marenzi and Cardini[1].

The quantity of fatty acids disappearing from the blood, by incubation with depleted adipose tissue for 3 hours, is between 1 and 2 mgm. The oxidation of fat by the tissue accounts for only 0·025 mgm. (calculated from the value of 0·18 mm.³ oxygen consumed per mgm. fat-depleted adipose tissue per hour). The main quantity of the disappearing fat must thus have been taken up by the tissue without any profound change.

The results of these experiments show that the penetration of fat into adipose tissue is an active process, depending on the physiological activity of the tissue.

The physiological and pathological conditions influencing this penetration are under investigation.

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[1] Marenzi, A. D., and Cardini, C. E., *Rev. Soc. Argent. Biol.*, **19**, 118 (1943).

Peripheral Action of Botulinum Toxin

AN investigation has been made of the pharmacological properties of *Cl. botulinum* (type *A*) toxin. Rabbits injected intravenously with the toxin developed severe œdema with focal hæmorrhages in the lungs. These lung lesions were also found when 'local' botulism was produced in a number of tissues, but with larger doses of toxin. It was therefore possible to achieve a local concentration of toxin sufficiently high to paralyse certain nerve-endings without killing the animals prematurely by the injury to the lungs.

Intra-ocular injections of the toxin produced a total paralysis of the nerves to the sphincter pupillæ, which failed to react to light or to stimulation of the oculomotor nerve. This action was analysed and was found to be due neither to any injury of the smooth muscle itself nor to a neuro-muscular block of the type produced by atropine (as suggested by Edmunds and Long[1]), since the sphincter reacted normally to acetylcholine.

The injurious effect of the toxin appears, therefore, to be on the cholinergic nerve fibres proper and is restricted to them, since stimulation of the cervical sympathetic nerve still dilates the pupil, and reflexes

originating from the cornea are not abolished. This shows that the adrenergic and sensory nerve fibres concerned, although exposed to the same concentration of toxin within the eye, are not affected in the same way as are the cholinergic fibres.

In similar experiments on voluntary (extrinsic ocular) muscles paralysed with toxin, normal responses to acetylcholine were recorded. This differentiates the botulinic effect on skeletal muscle from that of curare poisoning, and again points to a lesion of the motor nerve-endings which are cholinergic.

Lastly, it has been found that despite its high molecular weight (900,000–1,130,000 [2]), this protein is able to pass out of the eye into the general circulation, which suggests that it must be capable either of inducing a change in capillary permeability to allow its passage, or that it is broken down to a smaller diffusible molecule which is still neurotoxic.

It is hoped to publish a full account of this work elsewhere, and further investigations are in progress.

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Jan. 12.

[1] Edmunds, C. W., and Long, P. H., *J. Amer. Med. Assoc.*, **81**, 542 (1923).
[2] Kegeles, G. J., *J. Amer. Chem. Soc.*, **68**, 1670 (1946).

Secondary Thickening in Excised Tomato Roots

White[1] has stated that secondary thickening does not occur in excised root cultures. Some of our cultures of tomato ('Best of All') which had been kept without transfer for five to six months were recently submitted to anatomical investigation, and were found to have developed a considerable amount of secondary xylem, though the occurrence of properly differentiated secondary phloem has not yet been demonstrated. The nature and extent of the secondary xylem can be illustrated by reference to two examples.

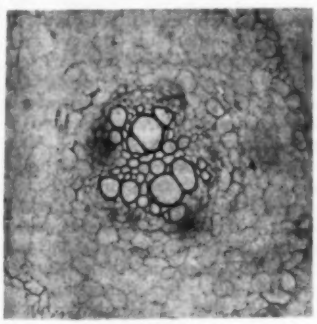

Fig. 1

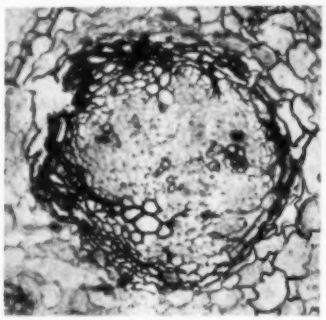

Fig. 2

Transverse sections of excised tomato roots. × 120

Root culture Passage 5, No. 41, growing on White's synthetic medium, exhibited in its older parts a patchy brown discoloration accompanied by a distinct thickening. Sections of these regions contained considerable quantities of secondary xylem. Most of the sections were characterized by an almost normal distribution of secondary xylem (Fig. 1), though some showed an anomalous condition in which a ring of lignified tissue containing vessels enclosed a central mass of thin-walled cells, the whole clearly formed by the activity of a cambium-like layer.

Culture Passage 1, No. 13, growing on White's yeast medium, also yielded some sections with normally distributed secondary xylem and others showing pronounced abnormality (Fig. 2). Here, on one side of the diarch primary xylem, repeated and disorderly cell divisions have produced a mass of callus-like tissue, only a few cells of which are differentiated into xylem elements. On the other side of the primary xylem, no corresponding development has occurred.

These examples demonstrate the occurrence of secondary xylem, but also show that the cambial activity is frequently seriously disorganised and results in the production of conspicuously abnormal structures. The exact age at which secondary thickening begins and the extent to which the process is influenced by cultural conditions are now under investigation, and will form the subject of a subsequent report.

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Dec. 11.

[1] White, P. R., "A Handbook of Plant Tissue Culture", 159 (1943).

Second Occurrence and Persistence of the Amphipod *Orchestia bottæ* M. Edwards in Britain

The amphipod *Orchestia bottæ* M. Edwards was first recorded in Britain by Gordon[1], who found it on the banks of the Thames at Richmond in 1942. This species, from the Mediterranean area, appears to be spreading and invading the freshwater systems of Europe. Dr. Gordon quotes records of its being taken in France (Cambrai, Nancy), Holland (80 km. from the sea), Belgium and Germany. The object of this note is to record that in July 1946 we found it in large numbers, adult and very young, in the damp roots of grass just above the water on the right bank of the Thames at Oxford, about half-way between Folly Bridge and Iffley Bridge; this is 92 miles upstream from the first lock (Teddington). In July 1947, one of us (A. J. C.) found it again in the same spot, still quite abundant though perhaps less so than in 1946. The severity of the spring had not apparently affected it.

We are indebted to Dr. G. M. Spooner of Plymouth for identifying our specimens. Dr. Gordon, of the British Museum, who has also seen specimens, confirms that it is the same species as that found by her at Richmond in 1942.

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Dec. 10.

[1] Gordon, I., *Proc. Linn. Soc. London*, Pt. 2 (Jan. 21, 1944).

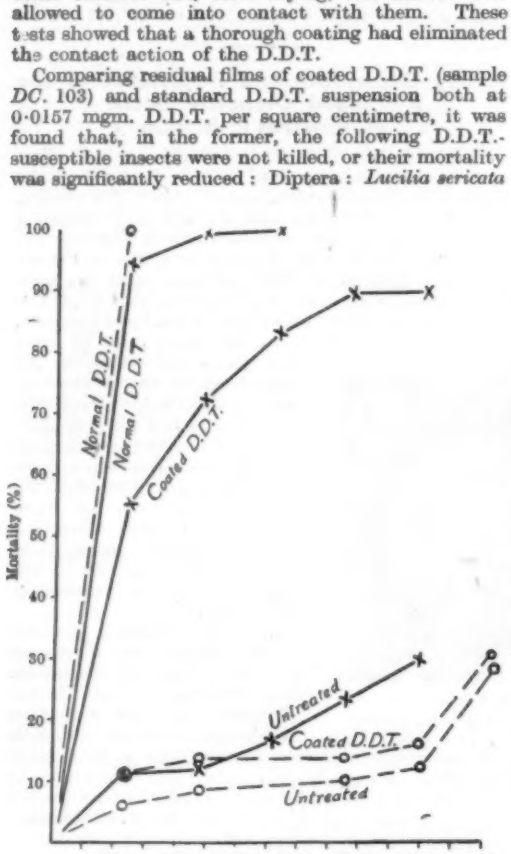
New Formulation of D.D.T. with Selective Properties

In order to produce insecticides which would be toxic only to certain groups of insects and not to others, it seemed a promising line of approach to make use of the known differences in the digestive capability of different insects. If individual particles of toxic compounds could be coated with substances digestible only by certain insects, then obviously only those insects would be killed by such coated insecticides.

Phytophagous insects are able to deal with hemicelluloses found in plant cell walls, and some wood-boring species also with celluloses, while carnivorous insects and insects such as most flies, bees and parasitic Hymenoptera cannot do so. Formulations of D.D.T. were therefore prepared in which the individual particles of D.D.T. were coated with degraded cellulose, by an acid precipitation of the degraded cellulose from alkaline solution to which a D.D.T. suspension had been added. A hardening process, carried out after acidification, greatly improved the characteristics of the coating.

These preparations were then sprayed on leaves or other surfaces and, after drying, test insects were allowed to come into contact with them. These tests showed that a thorough coating had eliminated the contact action of the D.D.T.

Comparing residual films of coated D.D.T. (sample *DC.* 103) and standard D.D.T. suspension both at 0·0157 mgm. D.D.T. per square centimetre, it was found that, in the former, the following D.D.T.-susceptible insects were not killed, or their mortality was significantly reduced: Diptera: *Lucilia sericata* Meig. (adults), *Syrphus* spp. (adults); Hymenoptera: *Apanteles glomeratus* Linn., *Apis mellifera* Linn., *Mormoniella vitripennis* Wlk. The same material sprayed at approximately the same rate on leaves which were then fed to larvæ of *Pieris brassicæ* Linn., *P. rapæ* Linn., and *Tortrix pronubana* Hübn., gave mortalities approaching those obtained with normal (uncoated) D.D.T. suspensions. Examples of the type of result obtained are shown in the accompanying diagram.



Effect on *Pieris brassicæ* larvæ (—x—) and on *Lucilia sericata* adults (– – o – –) of 'coated' and untreated D.D.T.

These experiments demonstrated that even the notoriously indiscriminate insecticide D.D.T. can be used as a selective insecticide specific to phytophagous insects. This development should prove useful in avoiding certain undesirable repercussions of D.D.T. spraying which are of considerable economic importance, such as outbreaks of other species of insects hitherto controlled by their natural enemies, for example, red spiders and mealy bugs after D.D.T. spraying of deciduous fruit against codling moth, and citrus against scale insect; or the rapid rebuilding of infestations of pests which are controlled by D.D.T. but are able to re-establish themselves because, in accordance with Volterra's Law of the Destruction of Averages, the simultaneous destruction of their natural enemies at the same rate as the destruction of the pests themselves leads to a more rapid building up of the pest population.

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Dec. 1.

Dependence of Anomaloscope Matching on Viewing-Distance or Field-Size

In a recent communication bearing the above title[1], we pointed out that with a particular anomaloscope the *R/G* ratio in the mixture required to match a narrow-band yellow depended on the viewing distance. Further work on more than forty normal observers has confirmed this effect, and also established the fact that the effect for each observer is substantially the same whether one eye is used or two eyes, as in the original investigation. Most observers required more green in the mixture the greater the viewing distance. Taking the *R/G* ratio as unity for an observer viewing an 18-mm. field at 50 cm. (subtending 2°), the ratio drops at a decreasing rate to an average value of about 0·85 at 300 cm. (20 ft.), beyond which there is little further change. The spread of results for different individuals is considerable, some observers dropping below 0·6.

We have now found that the introduction of a 3-mm. artificial pupil in front of the eye tends to reduce the lowering in *R/G* ratio, especially for those observers showing a particularly large drop. Thus, one of us (R. G. H.) finds that his *R/G* ratio, which normally drops to 0·6, only drops to 0·85 when using the artificial pupil, although at 50 cm. the ratio is unity in each case. A 3-mm. opaque stop, on the other hand, necessitates an even lower ratio for the match. Moreover, with the artificial pupil it appears that the *R/G* ratio is dependent simply on

the angle subtended by the field both for changes in field-diameter and viewing-distance, whereas with the natural pupil this is not so. This would indicate that part of the effect (in particular for those observers showing a large effect) is due to aberrations of the eye lens.

It may be that the effect would disappear if the chromatic aberrations of the eye were corrected, or possibly the explanation may involve the Stiles–Crawford effect.

Our thanks are due to Mr. D. W. O. Heddle for assistance with the observations.

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Nature, **160**, 23 (1947).

Mr. E. Westlake and the Geology of the Cantal Region, Central France

Information is sought as to the whereabouts of a paper on the geology of the Miocene–Pliocene gravels of the Cantal region of central France which was prepared by the late Mr. E. Westlake of Fordingbridge.

Mr. Westlake stayed for six months at Puy Boudieu in 1905, and accumulated many hundreds of the pieces of flaked chert, which in form and type of flaking closely resemble the specimens from the basement beds of the East Anglian Crag sands, and of the stone beds resting on the chalk beneath the Forest Bed and glacial deposits of the north Norfolk coast. The collection was studied at Oxford by the late Prof. W. J. Sollas, who referred to it in the third edition of his "Ancient Hunters". Owing to his death before the publication of a detailed account and analysis of the collection, the specimens were transferred to the Ipswich Museum, where the late Mr. J. Reid Moir undertook to produce a paper on them. This was written before Mr. Moir's death, and it is hoped now to secure its publication. The collection is available for study at the Ipswich Museum.

As many of the specimens bear the late Mr. Westlake's notes as to site and depth at which they were obtained, and it is clear that they were *in situ* finds, it is most important that the record of the observations made on the beds should be recovered. As it is known Mr. Moir had the MS. in his possession prior to his death, and as it cannot now be found among his papers, it is supposed he may have sent it or lent it to someone to read. Anyone who has any knowledge of its whereabouts, or has access to the papers of the late Prof. Sollas, or to any other likely source where it might possibly be, is asked to communicate at once with one of the undersigned.

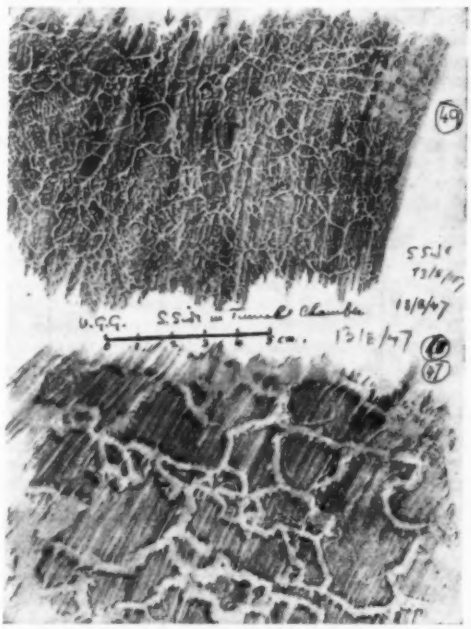
It is also known that drawings were prepared for the illustration of Mr. Moir's paper, and these are likewise missing. Any information about them would be valued.

G. Maynard
Ipswich Corporation Museum.
Aubrey T. Westlake
Godshill,
Fordingbridge.

Growth of Glacier Crystals

The mechanism of the growth of the ice crystal in glaciers is one of the most important of the unsolved problems of glacier physics. Its solution may also prove of value in sciences other than glaciology.

As a preliminary to an investigation into the causes of crystal growth, I spent some months in the Alps last summer making a statistical survey of the crystal sizes at the ends of a number of glaciers. Surprisingly enough, these are the only records which are known to exist. They brought to light several interesting facts, the chief of which are: (*a*) that the crystals in *flowing* ice are not nearly so large as had often been reported; (*b*) that under certain conditions they are surprisingly small; and (*c*) that there seems to be some relationship between crystal size and the inclination of the glacier bed.



Rubbings of crystals in the Upper Grindelwald Glacier

Obviously these tentative deductions need confirmation in other glaciers, and this note is written in the hope that observations may be started in as many widely separated regions as possible. Investigations adequate for preliminary purposes are very simple. The process of recording ice crystal sizes consists of making rubbings with a pencil on paper. Under favourable conditions a single sample can be recorded in ten minutes, and the process need seldom take more than half an hour.

I should be pleased if exploration parties or private investigators who are willing to co-operate, especially those visiting glaciers other than those of the Swiss Alps, would communicate with me, so that I can provide detailed instructions for making rubbings and for the compilation of the data necessary for the analysis of the results.

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DISINTEGRATION OF HIGHLY EXCITED NUCLEI

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IN a previous note[1], it was shown that most of the energy spectrum of protons ejected in nuclear disintegration stars produced in photographic emulsion by cosmic radiation could be explained in a general way by a simple evaporation process. We have now made detailed measurements on the angular distributions of the emitted particles, and compared them with what one would expect from the evaporation model of the nucleus.

Our data were obtained from twenty-four stars, each involving the emission of between fifteen and twenty-two charged particles from nuclei of silver, bromine and iodine present in the emulsion. These stars, which correspond to excitation energies of the same order of magnitude as the nuclear binding energies, represent about 2 per cent of the total observed in our plates, which were exposed for periods of forty days at altitudes of 3,500 m. and 4,400 m. at L'Aiguille du Midi, Chamonix.

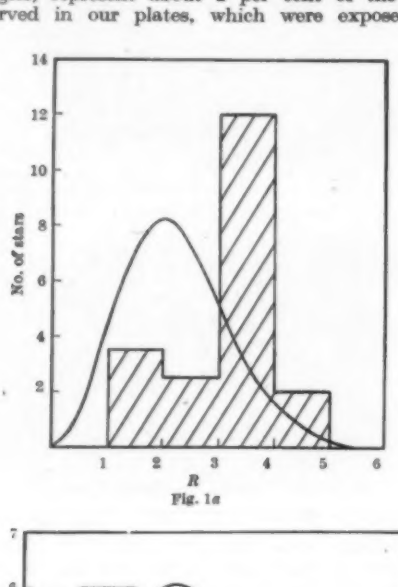

Fig. 1a

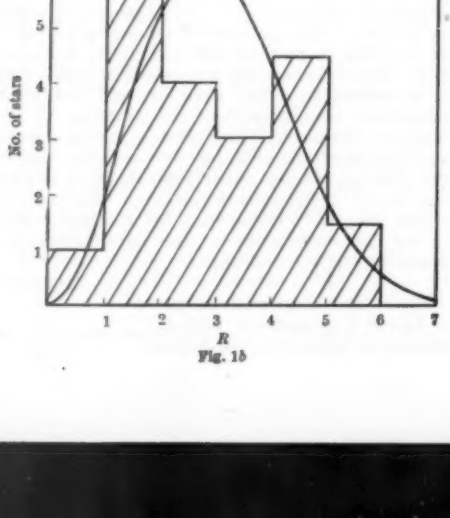

Fig. 1b

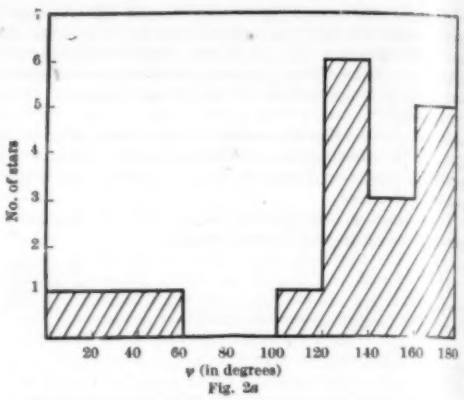

Fig. 2a

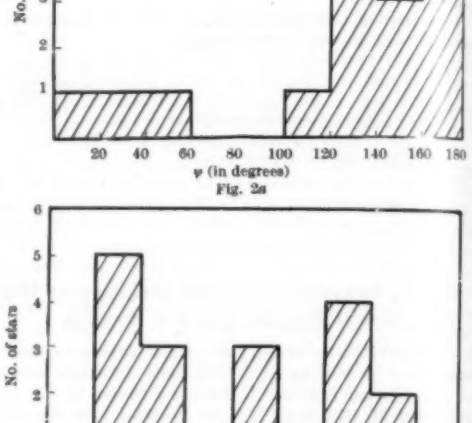

Fig. 2b

If the disintegration of a nucleus can be represented as a simple evaporation process, the angular distribution of the star particles should be, on the average, spherically symmetrical. Thus, if to each track is ascribed a vector of unit length, then the resultant of all the vectors of the star should have a scalar magnitude R, the probability distribution of which is determined by the random-walk theory[2]. The complete orientation of all tracks was determined by means of a goniometer eyepiece and by depth measurements in the emulsion, and a value of R calculated for each star. In determining the angular distributions we distinguish between the tracks of protons, alpha-particles and heavier nuclei, and the very heavy 'recoil fragments'; the latter are characterized by their short, heavily ionized tracks, which frequently show considerable Coulomb scattering owing to their high charge. In Fig. 1*a* the histogram shows the distribution of R for alpha-particles only; in (*b*) that for protons only. A comparison of the histogram with the random-walk curve shows that the alpha-particles have angular distributions with large deviations from spherical symmetry (the probability that the histogram corresponds to spherical symmetry is less than 10^{-4} from the χ^2 test). On the other hand, the protons are seen to be emitted almost isotropically.

Here it must be pointed out that the observed asymmetry cannot be due to the momentum transfer from the incident particle. Even the most energetic stars entail an excitation of only 1,000 MeV. Thus the velocity imparted to the whole silver nucleus by, say, an incident neutron would be $< 0{\cdot}01$ c., which

is very small compared with that of each ejected particle ($\sim 0{\cdot}2$ c.). Furthermore, the sums of the components of R over all the stars, in horizontal and vertical directions respectively, show no essential difference.

In order to determine whether the alpha-particles are collimated in any special direction, we have calculated, for each star, the angle ψ between the short recoil fragment (or fragments) and the resultant direction of the alpha-particles. The distribution of ψ over all stars with observable recoil fragments is indicated in Fig. 2*a*. The alpha-particles show a strong tendency to be ejected in a direction opposite to that of the recoil fragment. On the other hand, as might be expected, the protons do not appear to show any such directional effects (Fig. 2*b*).

A possible explanation of the collimation of the alpha-particles and heavier sub-nuclei is that the first stage in the disintegration process consists of the breaking up of the nucleus into two or more heavy fragments. Each may be supposed to have considerable momentum, and we must further assume the fragments to be of different sizes, and the excitation energy to be asymmetrically divided between them. We then postulate that the lighter fragments, which must necessarily carry most of the kinetic energy, break up spontaneously, preferentially into stable particles with low internal energy, such as alpha-particles, but possibly also a few protons and neutrons. The heavy 'recoil fragment', on the other hand, retains most of the original excitation energy as internal energy, and then 'cools down' by evaporating off neutrons and protons (and, of course, a few alpha-particles). The angular distribution of the protons would then be more or less isotropic, as observed. From the charge carried away by the alpha-particles and protons, it is possible to estimate that on the recoil fragments. We find that their ranges are roughly in agreement with what one would expect, if their momenta were equal and opposite to that of the alpha-particles.

If the above hypothesis is true, one would not expect the energy distribution of the alpha-particles to conform to evaporation theory. In actual fact, measurements on the ranges of the alpha-particles yield an energy spectrum which appears to be much broader than could correspond to an evaporation process. However, it will be necessary to improve the statistical accuracy of our data in order to confirm this.

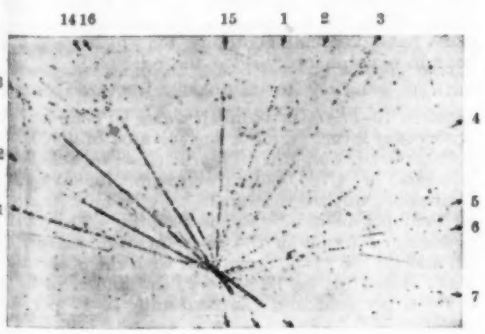

Fig. 3. Disintegration of silver or bromine nucleus in Ilford *B*2 emulsion, in which both the alpha-particles (11–15) and protons (1–8) are strongly collimated. Particle 16 ends in the emulsion and is probably a very slow meson. Tracks 9 and 10 are those of heavy recoil fragments

It must also be emphasized that not all our disintegrations conform to the above scheme. In a few cases no recoil fragment is visible, and in one extreme example (Fig. 3) the protons as well as the alpha-particles show strong collimation.

The excitation energy required in the processes we have described is estimated at 500–1,000 MeV. Now, the great majority of stars produced by 200 MeV. deuterons and 400 MeV. alpha-particles from the Berkeley cyclotron show forks with only three or four charged particles; no large stars have been reported[3]. As explained by Serber[4], this is because the nuclei become partly transparent to the incident nucleons with these energies. In a similar way, a σ-meson, when captured into a nucleus, would appear to undergo annihilation by interaction with a single nucleon, which is excited to an energy $\sim$ 200 MeV. This nucleon will then leave the nucleus after only one or two collisions, with an energy loss of only some tens of million electron volts. Thus our own observations, and those of Dr. Powell and co-workers[5], show that stars produced by σ-meson capture generally involve only two or three charged particles. Very rarely are more than four secondaries produced. These two experimental facts indicate that it is unlikely that the energetic stars can be explained by nuclear capture of, for example, neutrons with energies of a few hundred million electron volts, or nuclear capture and annihilation of neutral or fast charged mesons with the usual values of mass. Probably, therefore, the stars described above are the results of another process, for example, the inelastic scattering of very fast cosmic-ray particles, with energies in the relativistic region where the cross-section for scattering on nucleons becomes large.

It is hoped to publish a fuller account of this work in the near future.

[1] *Nature*, **160**, 299 (1947).
[2] Chandrasekhar, *Rev. Mod. Phys.*, **15**, 1 (1943).
[3] Gardner, *Bull. Amer. Phys. Soc.* (Jan. 2, 1948).
[4] Serber, *Phys. Rev.*, **72**, 1114 (1947).
[5] Lattes, Occhialini and Powell, *Nature*, **160**, 486 (1947).

RELATIONSHIPS OF VAPOUR PRESSURE, CAPILLARITY AND TEMPERATURE IN CLAYS

By B. VASSILIOU and Dr. J. WHITE

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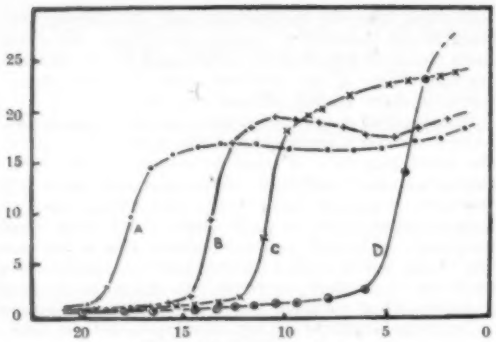
WHEN columns of a commercial kaolin ('Supreme Kaolin') of uniform moisture content are placed in sealed, vertical tubes, along which a constant temperature gradient is maintained, and having a reservoir of water at constant temperature at their lower, cool ends out of contact with the clay, 'stepped' moisture distribution curves of the type shown in the accompanying diagram are obtained, the step moving progressively, but with decreasing velocity, towards the cool end of the tube with increasing time.

It has been found that the observed distributions can be accounted for in terms of the relation

$$\log_{10}P = -\frac{2252}{T} + 7{\cdot}92 - \frac{2{\cdot}146 \times 10^{-5}}{rT} + \frac{2{\cdot}677 \times 10^{-6}}{r} - \frac{1{\cdot}258 \times 10^{-2}}{T}(P_0 - P), \quad (1)$$



MOISTURE DISTRIBUTION IN CLAY COLUMNS UNDER A TEMPERATURE GRADIENT

	Initial water	Time (hr.)
A	16·0	35
B	16·0	125
C	17·8	288
D	17·8	1013

if the vapour pressure is assumed constant from the position of the inflexion near the top of the step to the hot end of the column. This equation was derived from the ordinary vapour-pressure/capillary-radius relation using the approximate substitutions

$$\gamma = 114{\cdot}4 - 0{\cdot}1425\,T$$

$$\text{and } \log_{10}P_0 = -\frac{2252}{T} + 7{\cdot}92,$$

P being the vapour pressure in cm. of mercury in a capillary of radius r cm. at $T°$ abs., P_0 the vapour pressure over a plane water surface at the same temperature and γ the surface tension in dynes/cm. Over the range of vapour pressures involved, the last term on the right-hand side of equation (1) could be neglected. Since earlier work had shown that lowering of the vapour pressure was negligible with this clay at more than 3–4 per cent water, P could be taken as that of a plane water surface at the temperature of the inflexion. Using the appropriate values of P, r was calculated for various positions of known temperature along the column, the curves obtained being of similar form to those reproduced, except that the moisture variation was expressed in terms of r instead of actual moisture contents. By direct comparison of calculated r values with the moisture contents on corresponding curves, the expression

$$r \times 10^7 = 2{\cdot}0\ W^{1\cdot57}, \qquad (2)$$

where r is the effective capillary radius in cm., and W the weight percentage of water has been derived. Applied to the calculated data, this expression gives an excellent fit with the curves shown and also with curves obtained when the whole of the column had come to equilibrium with the reservoir.

Some light on the underlying rate-mechanism has been obtained from experiments in which water alone or a clay–water mixture was placed in trays evenly spaced along the tubes (equivalent to using a broken column). Movement of water could then take place only by an evaporation–condensation mechanism via the narrow annular spaces round the trays. On plotting the moisture contents of the trays against their position in the tube at various times, curves similar in form to those shown were obtained.

With water alone, the evaporation-rate from each tray was constant until it was dry, the rate varying from tray to tray as a linear function of the vapour pressure. Of the moisture evaporating from any tray, approximately one half condensed in the first tray below, one quarter in the second and one eighth in the third, the remainder passing apparently direct to the reservoir, as no condensation on the tube was found. The movement of the step from the fourth tray onwards is, therefore, given by the equation

$$t_n = cW \times 1{\cdot}20 \times 10^{-8} \left[\frac{5}{12}n + \frac{61}{72} - \frac{2}{9}\left(-\frac{1}{2}\right)^n\right] \exp 5190/T_n. \qquad (3)$$

t_n being the time in hours for the nth tray at T_n to become dry, W the initial weight of water in each tray and c a constant equal to 1870. A similar type of equation can be made to fit the movement of the step on the curves shown, and it would appear that movement of the water is an activated process (evaporation–condensation or activated diffusion) involving water which is 'bound' to the clay particles. At higher moisture contents where free flow is possible (necessitating horizontal tubes) no 'stepped' distribution is developed until the moisture content has been reduced by drying.

With a clay–water mixture in the trays, similar relationships hold except that the evaporation-rate for each tray decreases rapidly at less than 3–4 per cent water due to lowering of the vapour pressure by capillarity. During this stage, the vapour pressure of any tray approaches equilibrium with that of the nearest tray still in its constant-rate period of drying at a vapour pressure senably that of a plane water surface. From the drying curves it has, therefore, been possible to determine the vapour pressure of the clay at various temperatures and water contents. From this data the expression

$$\Delta H - 10{,}300 = \frac{2350}{W - 0{\cdot}79} \qquad (4)$$

has been derived, where ΔH is the total heat of evaporation in cal. per mol. of water when there are W gm. water per 100 gm. clay.

The form of the denominator in equation (4) implies a lower limit to capillarity at $W = 0{\cdot}79$. Equation (2), on the other hand, indicates a continuous rise of r with water content, slow at first, then rapid. Actually at more than 1 per cent water the data can be fitted reasonably by a straight line cutting the axis of zero r at approximately 0·79 per cent water. This value has been taken tentatively as indicating completion of a monomolecular adsorption layer on the clay surface, giving a value of the order of 300,000 sq. cm./gm. for this clay. On the same basis, Pembina bentonite, for which continuous column experiments yielded the relation

$$r \times 10^7 = 0{\cdot}00022\ W^{2\cdot3}, \qquad (5)$$

requires 16–17 times as much water to complete the adsorption layer, giving a surface area of 4,800,000–5,100,000 sq. cm./gm. This is close to Schofield's estimate of 4,700,000 sq. cm./gm. for Wyoming bentonite[1], but the agreement may be only apparent as Pembina bentonite is non-swelling. The vapour pressure isotherms of the two clays calculated from (2) and (5) for 20° C. agree well with the observation that, stored in the laboratory, the kaolin picks up 0·9–1·0 per cent and the bentonite 16–17 per cent moisture.

A full account of the work will be published in due course. One of the authors (B. V.) acknowledges with gratitude the award of a British Council scholarship.

[1] Schofield, R. K., *Nature*, **160** 408 (1947).

RELATION OF MANGANESE AND SOME OTHER METALS TO THE IRON STATUS OF PLANTS

By ERIC J. HEWITT

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IT has been shown with plants growing in water culture that iron deficiency symptoms may be readily induced by excessive concentrations of manganous salts[1-6]. A reciprocal effect on the incidence of manganese deficiency in the presence of high concentrations of iron compounds has also been shown for soya bean[6] and some fruit crops[4]. These results have been interpreted[6] as suggesting that iron deficiency and manganese toxicity are but relative terms for the same disorder resulting from too wide Fe/Mn ratios, and that manganese deficiency and iron toxicity are similarly relative. It is generally assumed that metabolically active iron exists in plants in the ferrous state, and becomes inactive after oxidation to the ferric state. In one of the experiments referred to[6], this oxidation was assumed to follow reaction with manganese compounds previously oxidized to a higher valency state. A similar ability to induce iron deficiency was forecast for cobalt on account of its still higher oxidation-reduction potential than the manganese system postulated, and some indication was obtained that iron deficiency was induced more readily by cobalt salts.

In other experiments using sand or water culture, it has been shown that compounds of metals such as copper[7,8], zinc[5,7,9,10], and chromium[11,32] can also induce symptoms apparently identical with those of iron deficiency. Observations in the field[10,12,13,14,15] also confirm that similar symptoms may be induced in a variety of crop plants by toxic levels of compounds of copper or zinc in soil, and possibly by other metals in industrial sewage spread over land in which such crops are growing; similar effects may also appear in the vicinity of copper and zinc smelting works, and in areas where zinc-bearing dolomitic limestone occurs[15]. Naturally occurring compounds of cobalt or nickel may also cause this effect in acid soils[16]. It is thus evident that the compounds of several metals, in addition to manganese and cobalt, may induce iron deficiency. Furthermore, recent results obtained with several crop plants grown in sand culture[12,17,18] have shown that symptoms of manganese toxicity can be distinguished from those of manganese-induced iron deficiency and are readily produced even in the absence of the latter. It thus seems necessary to examine more fully the relation of the effects of 'toxic' concentrations of a number of metallic ions to iron metabolism and the appearance of the visual symptoms of this deficiency and of other injurious effects. Results are given below of some experiments made in sand culture with sugar beet, chosen because it shows readily symptoms of iron deficiency in the field in the presence of some of the metals mentioned, and is known to be remarkably tolerant to high concentrations of manganous ions[12].

Experimental. Young sugar beet seedlings were transplanted into purified sand[19] in 10-in. bitumen-painted clay pots[19], and the cultures arranged in two series according to two types of iron supply, as follows: Series 1: Purified sand only, with iron supplied as ferric citrate at 0·1 milli-equiv. per litre in the complete nutrient solution. Series 2: Purified sand mixed with magnetite at the rate of 100 p.p.m., but no iron added in the nutrient solution. In both series the ions Pb^{++}, Zn^{++}, Cu^{++}, Co^{++}, Ni^{++}, Mn^{++}, Cr^{+++} and CrO_4'' (the last to supply the same weight of chromium as the Cr^{+++}) were added separately, at concentrations of 0·5 and 1·0 milli-equiv. per litre in the nutrient solution. There were also three control treatments without any of these additions, and in which iron was supplied as above, either as magnetite, or as ferric citrate, or was omitted altogether.

Plants in the control treatment where iron was omitted developed acute symptoms of chlorosis and also some brown intervenal necrosis typical of iron deficiency. Control plants given iron, either as citrate or as magnetite, grew vigorously and the foliage was normal. Chlorosis of younger leaves, typical of iron deficiency, developed in all plants given the additional ions listed above, and ranged from very severe (total yellow) to a trace. The severity of chlorosis was observed to be in the order of

$$Co^{++} > Cu^{++} > Zn^{++} = CrO_4'' > Ni^{++} > Cr^{+++} > Mn^{++} > Pb^{++};$$

that of the controls where iron was omitted was similar to plants given extra Zn^{++} or CrO_4''. This same order was shown in both the citrate and magnetite series, although certain broad differences were noted between the two series. Thus in the citrate series, the chlorosis caused by the chromic or manganous ions, and the differential effect of using two concentrations, were more marked. The effects of copper, zinc or chromate respectively were comparable in the two series, but cobalt and nickel produced more severe injury in the magnetite series than with citrate. Evidence was obtained, by painting the leaf surface with 0·25 per cent ferrous sulphate solution plus a wetting agent, that the chlorosis was *in all cases* due to failure in the iron metabolism. A response was evident in about forty-eight hours, and complete recovery of the treated areas occurred in five days, while untreated leaves, including the younger ones, remained chlorotic.

In addition to the induced chlorosis, other apparently direct toxic effects were noted in the Co^{++}, Ni^{++}, Zn^{++}, Cu^{++} and CrO_4'' treatments; here the plants were considerably dwarfed, whereas those given Cr^{+++}, Mn^{++} or Pb^{++} grew with normal vigour. Brown intervenal necrosis usually developed in the chlorotic leaves, including those of control plants lacking iron. This necrosis ranged from very severe with cobalt or nickel, to slight or nil with chromium as sulphate, manganese or lead. In the presence of nickel the necrosis appeared rapidly and frequently preceded marked chlorosis, and, when cobalt was given, both necrosis and chlorosis were quick to appear. The necrosis was unusually dark brown or even black in colour in these two latter treatments, and eventually resulted in complete blackening and death of the young leaves and of the plants. Fading, tinting and necrosis also developed in the older leaves of plants given zinc, cobalt or nickel, the last element in particular producing an orange tinting of the faded older leaves. These symptoms were all distinct from those identified as resulting from iron deficiency. A similar distinction has been noted for flax suffering from zinc toxicity[10]. The general order of toxicity, as distinct from induced chlorosis, was as follows:

$Ni^{++} > Co^{++} \geqslant Zn^{++} > Cu^{++} > CrO_4^{--} \geqslant Cr^{+++} = Mn^{++}$ and Pb^{++}.

As previously stated, sugar beet has been found to be relatively tolerant to high concentrations of manganous salts. Symptoms of manganese toxicity distinct from and without those of iron deficiency, however, were produced in another experiment in the *older leaves* of plants given 6 milli-equiv. per litre of manganese in the presence of an adequate iron supply[12]. These observations have confirmed previous conclusions that manganese toxicity and manganese-induced iron deficiency are distinct effects[15,17].

Symptoms which appeared in some of the older leaves of the plants given extra zinc resembled the effects of manganese deficiency and occurred simultaneously with iron-deficiency symptoms in the young leaves of the same plant. Determinations of soluble manganese[16] showed that the affected leaves yielded less than 0·015 and 0·005 p.p.m. of manganese in the tissue extract when given 0·5 and 1·0 milli-equiv. per litre Zn^{++} respectively, as compared with 0·05 p.p.m. in leaves from the control (ferric citrate only) plants. The simultaneous deficiency of iron and manganese in the same plant was observed in another experiment[12] with oat plants grown in sand cultures from which both elements were omitted. In this latter instance, typical iron-deficiency chlorosis and 'grey speck' could be distinguished on the same leaves, and a similar condition was identified in the field in 1946 and 1947, where liming had been used in an attempt to control injury by industrial sewage[12]. Specific morphological effects ascribed to the simultaneous deficiency of these elements have also been described for leaves of *Theobroma cacao*[21].

Discussion. The suggestion that oxidation-reduction reactions may be responsible for the iron-deficiency chlorosis induced by manganese and cobalt may be considered on the basis of this new evidence. It is clear that manganese and cobalt are in no way unique in their capacity to induce such chlorosis and that, of the metals examined, at least one, namely zinc, does not undergo valency changes associated with simple oxidation-reduction reactions; of the others, manganese was one of the least active, while copper and cobalt were the most active in producing chlorosis. These results bear no relation to the E_0 values given by Latimer[22] for changes in valency of the *simple ions*. Thus the E_0 values for $Co^{++} \rightarrow Co^{+++}$, $Cu^{+} \rightarrow Cu^{++}$ and $Mn^{++} \rightarrow Mn^{+++}$ are $-1{\cdot}84$, $-0{\cdot}167$ and $-1{\cdot}51$ V. respectively, whereas for $Fe^{++} \rightarrow Fe^{+++}$, $E_0 = -0{\cdot}77$ V. Thus copper, even as the cupric ion, should, on that theory at least, be incapable of converting the ferrous to the ferric ion; while it must be assumed that, as the cobalt and manganese were given in the reduced valency form, they must first have been oxidized in the plant to a higher valency by reactions that, in the absence of these metals, do not influence the ferrous-ferric equilibrium. Furthermore, the existence of some of the high-valency metallic ions in living plants is doubtful. Nickel, for example, caused chlorosis, but tetravalent nickel exists only as NiO_2 under strongly alkaline conditions, and the cobaltic ion can attack water.

On the other hand, many of the metals studied would exist as complex ions in the plant. The oxidation-reduction potentials of complex ions, however, may often differ greatly from those of the simple ions. For example, for

$Co(NH_3)_6^{++} = Co(NH_3)_6^{+++} + e^-, E_0 = -0{\cdot}1$ V.,

while for the $Fe^{++} \rightarrow Fe^{+++}$ change when iron is present as a complex with *o*-phenanthrolene, $E_0 = -1{\cdot}14$ V. Thus it is clear that explanation of the observed facts must await more accurate information on the form of combination of the metals involved and on their metabolism.

A suggestion that active iron in plant tissues may be closely associated with certain protein fractions[1] requires that the possible influence of various metals on the precipitation, denaturization, or adsorptive properties of such protein fractions should also be borne in mind. Competition between the toxic metal ions and iron in enzyme systems involved in chlorophyll formation, or the activation of enzyme systems influencing the ferrous-ferric iron equilibrium may also be important in reactions inducing symptoms of iron deficiency. It is not, however, justifiable at this stage to infer that the mechanism causing chlorosis is analogous in each case. Thus data showing increased iron accumulation in the presence of toxic concentrations of zinc[10,15] would seem to exclude simple antagonism as a cause of chlorosis in some instances, while the differential response to Cr^{+++} and Mn^{++} in the presence of magnetite or ferric citrate suggests that antagonism may still be significant in others, and work on copper-induced chlorosis[9] suggests that two separate effects may be involved.

Conclusions. The evidence considered here points to the following conclusions: (1) Manganese is not unique in its ability to induce iron-deficiency symptoms, and may, in fact, be less active in this respect than many other metals. (2) The existence of the simultaneous deficiencies of iron and manganese in the same plant has been observed in a number of independent instances, which suggests that these elements have some independent functions in plant metabolism. (3) Toxic effects of excess manganese can be readily distinguished from symptoms of iron deficiency; again suggesting independent effects of these elements. (4) Hypotheses based on oxidation-reduction potentials of *simple ions* appear inadequate to explain the activity of the metals considered herein in inducing iron deficiency, and more than one mechanism may be involved.

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NATIONAL RESEARCH COUNCIL OF CANADA

ANNUAL REPORT

THE thirtieth annual report of the National Research Council of Canada, 1946–47, includes the report of the president, Dr. C. J. Mackenzie, together with the financial statement for the year ended March 31, 1947 (Ottawa: National Research Council). Dr. Mackenzie's report gives a general conspectus of the work of the Council, but for scientific workers and others interested in details of the projects in progress, a more comprehensive booklet, "The National Research Council Review for 1946", is available on order from the Council. At the end of the War, a Defence Research Organisation was formed under the Department of National Defence, and is responsible for determining what research is to be done for military purposes during peace-time. The president of the Research Council is *ex officio* a member of this Board. Associate committees with purely war-time functions which had completed their assigned tasks have now been disbanded, but at the end of 1946 there were thirty-three active committees. Eighty-one research grants were made in 1946–47 directly by the Council, 82 through the Division of Medical Research and 93 through committees, while scholarships were awarded to 185 graduate students to enable them to extend their training in research.

Conversion of the Council's activities from war to peace was completed during the year, but the Council is at present recruiting the personnel required to bring its peace-time establishment to full strength. An Atomic Energy Research Division has been established at Chalk River to investigate the applications of atomic energy and the use of its products in industry and medicine. The Council took over on February 1, 1947, full responsibility for the administration and operation of atomic energy development at Chalk River, and will carry on these activities in accordance with broad general policies fixed from time to time by the Atomic Energy Control Board. A Division of Medical Research has been organised to stimulate and support investigations in this field, and has set up, at the request of the manufacturers, a committee to advise on the distribution of streptomycin and to make recommendations as to clinical conditions for which streptomycin might be used. A Building Research Division is being established, and work is progressing on the construction of a Prairie Regional Laboratory at Saskatoon for the promotion of studies on the better utilization of agricultural surpluses, notably wheat, and farm waste products such as straw. The newly established Division of Information Services has substantially expanded its survey of German and other reports for the solution of specific manufacturing problems.

An Electrical Engineering and Radio Branch has been created to co-ordinate and direct work in this field. The most important contribution in the development of radio aids to air and marine navigation during the year was a radar distance indicator, which enables an aircraft pilot to ascertain his distance from one or more pre-selected ground stations, its distance being read directly in miles on a simple meter. The Council is also co-operating in the development of radar equipment, by means of which it is hoped to determine base lines up to 300 miles long with an accuracy of 20 ft., and to permit spot fixes of photographic aircraft with an accuracy of 100 ft. in 200 miles. The laboratory is also engaged in developing a radio altimeter capable of providing a continuously recorded altitude measurement accurate within 50 ft. In the Division of Physics and Electrical Engineering, work has been undertaken to provide first-class facilities for scientific standardization, and a new project with a magnetic airborne detector is directed to the scientific determination from the air of the earth's magnetic elements and the location of mineral and oil deposits. Two experimental buildings of the radiant-heating project have been constructed, and work has been resumed on the thermostatic control of heated refrigerator cars. An infra-red detector was used successfully to ascertain whether joints were heating on transmission lines, and an apparatus has been completed by means of which the thermal conductivity of metals can be measured up to 800°.

A programme of photographic research is under way to determine the important factors in making positive prints on paper so that the maximum amount of information can be recovered from the negative, and a paper describing the final techniques developed for night photography is being published. Studies have been made of the factors affecting the dimensional stability of film under actual survey conditions, and further work has been done on the measurement of emulsion speed for aerial photography by a resolving power criterion, as well as on photometric standardization. Work in colorimetry has been initiated, and the Canadian Photographic Research Committee has been replaced by an Associate Committee on Photographic Research.

In the Division of Applied Biology one group is primarily concerned with fats and oils, and work on the processing and treatment of domestic oils for edible purposes has continued, particularly attempts to obtain an edible fraction from linseed oil and another fraction with superior properties for use in the paint industry. Work has continued on egg products, pork products and dairy products, particularly butter and dried milk. Preliminary trials of a Fritz butter-making machine from Germany indicated that the difficulties in meeting Canadian standards can be overcome. Efforts are being made to improve the versatility of chemical methods of assaying for riboflavin, thiamin and niacin. In the Ottawa laboratories, pilot plant studies on the production of *l*-2 : 3-butylene glycol from wheat with *Aerobacillus polymyxa* were completed, and fermentation efficiencies of 90–100 per cent were consistently attained. A method has been developed for the manufacture of phthalate resin from 2 : 3-butylene glycol and phthalic anhydride which has outstanding physical properties and is of interest to paint manufacturers. Wheat syrup was investigated on a semi-pilot plant scale, and first-quality corn syrups were prepared from the starch separated.

The reorganisation of the Division of Chemistry into Fundamental Chemistry and Chemical Engineering was completed, and the organic section of the former branch has investigated synthetic rubber and the isolation of new alkaloids. Many studies of photosensitized reactions have been made, including investigations of free radical processes by the mirror technique. Studies in surface chemistry have included the effect of physical adsorption on the electrical conductivity of activated carbon rods; but the work of the inorganic section, like that of the chemical

engineering branch, has been concerned with the atomic energy project. The textile section has carried out further work on the rot-proofing of textiles, thermal insulation of protective clothing, the use of synthetic detergents, water-repellants and moth-proofing agents. The corrosion of steel by water is being studied under static and under flow conditions, including the mechanism of corrosion inhibitors. Preliminary data have been obtained on a new type of catalyst for the oxidation of ethylene to ethylene oxide, and an extensive research has been continued on the chemistry of long-chain unsaturated fatty acids. Further work on a new type of propeller de-icing, on the control of frost on standing aircraft, the development of an effective rain repellant for aircraft windows and of a catalyst for the oxidation of carbon monoxide to permit accurate determination of low concentrations in air, promise important peace-time applications. The relation between chemical structure and plasticizer reaction is being studied, while in the aeronautical laboratories the tailless glider was one of the major projects. The hydraulics laboratory completed tests on a model of a Great Lakes' harbour to determine the effect of a proposed pier extension upon sand-bar formation in the harbour entrance. Research on low-temperature lubricants has yielded much valuable information on flow characteristics of greases at low temperatures. Work on artificial limbs has continued in the structures laboratory, making use of processes developed during research on moulded aircraft components. Problems involved in 'panel', or radiant, heating are being investigated, and an important advance in low-cost housing was made in the development of a modular system for the construction of pre-fabricated houses.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

ANNUAL REPORT

THE work of the British Electrical and Allied Industries Research Association throughout the year ended on September 30, 1947, is recorded in the twenty-seventh annual report recently issued.

The field of activity of the Association is perhaps most readily appreciated from a block diagram given in the report, in which twenty-two main lines of research are represented, several of which divide into as many as ten distinct branches. These include extensive studies of insulating and magnetic materials and of gaseous discharge phenomena, in regard to which researches of both a fundamental and of an applied character are in progress. Surge phenomena, communication interference, earthing safety and circuit problems, overhead lines, power plant and rural electrification are also main subjects of investigation.

In the section on heating, cooking and allied problems, reference is made to work in progress on a heat pump installation and to the early publication of a final report on an experimental investigation of the thermal characteristics of a concrete floor heated by buried cables. In connexion with the work on surge phenomena it is reported that a recurrent surge oscillograph has been developed which employs a sealed-off tube and gives a performance comparable with that obtained with the continuously evacuated type of instrument. Integrating electricity meters provide the subjects of several extensive investigations. A number of these is concerned with the behaviour of instrument jewels, the initiation of a new series of tests on tungsten/diamond and tungsten/sapphire bearings being reported. A detailed examination of the parasitic forces occurring in induction-type watt-hour meters has also been made.

It is interesting to note the wide range of researches supported by the Association in various university departments throughout Britain. These include investigations on the properties of high-pressure, high-temperature steam, work on the fundamental properties of magnetic materials and on the improvement of electrical sheet steels. Studies on the development of spark discharges include an investigation of the build-up of ionization by the Wilson cloud-chamber technique, and work on the high-frequency corona discharge. Experiments on the use of artificial illumination in horticulture are also being conducted in one university department.

In the introduction, the first paragraph deals with the reaction upon the Electrical Research Association of the transfer of the electrical supply industry in Britain to public ownership. The supply industry has provided some 30 per cent of the income of the Association, and the future relation of the British Electricity Authority with the Association is therefore of great importance. It is reported that the chairman of the Authority has confirmed the intention to support the Association and has provided for the safeguarding of the Association's finances during a transitional period in which the new basis will be worked out. The present report testifies to the existence within the electrical industry, both in the supply and the manufacturing spheres, of a spirit of co-operation in research which has built up, by good will and patient effort, a powerful instrument for the scientific and technical advancement of the industry as a whole. Such an achievement is a contribution, by no means inconsiderable, to the vital industrial needs of Great Britain at the present time.

J. G.

Rh NOMENCLATURE

FOLLOWING the hearing of evidence from interested persons, W. B. Castle, M. W. Wintrobe and L. H. Snyder have reported[1] to the Surgeon-General of the U.S. Public Health Service on the nomenclature of the anti-*Rh* typing sera. The report traces the history of *Rh* nomenclature, summarizes the evidence for and against Wiener's and Fisher's nomenclature respectively, and recommends that the Wiener nomenclature shall appear first on the label of serum containers, followed by the Fisher terminology in parentheses, thus: "Anti-Rh_0 (Anti-D)".

The authors have, on the whole, presented a fair and accurate summary of the complex history of the development of *Rh* theory and nomenclature, and of the associated controversies. They have, however, not pointed out that Fisher's notation was put forward[2] a year or more before any discussion of the possible genetic situations. Fisher's essential contribution lies in his postulation of three pairs of antigens, the antigens of each pair separately behaving as though they were the products of a pair of allelomorphic genes. Neither the validity nor the great

convenience of Fisher's notation depends on the precise cytological basis of these facts. The most likely explanation consists in the existence of three very closely linked loci, but one cannot at present rule out the possibility of some such mechanism as that of a single gene with three side-chains each capable of variation. Even for this type of mechanism, Fisher's notation would give a more complete and convenient specification than that of Wiener. It should also be pointed out that Wiener's present nomenclature differs greatly from that originally put forward, and a claim of priority for it can scarcely be based on the fact that his original system was published before that of Fisher.

The compromise reached is an advance on previous American practice, and indirectly will do much to enable workers on the *Rh* factor in different parts of the world to understand one another's language. It is, however, to be regretted that Fisher's notation is relegated to parentheses; while its obvious advantages will ensure its use in research work, the first name on the label will tend to be perpetuated among clinical pathologists. A. E. MOURANT

[1] Castle, W. B., Wintrobe, M. W., and Snyder, L. H., *Science*, **107**, 27 (1948).

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PROPOSED INSTITUTE OF RECORDED SOUND

THE Association of Special Libraries and Information Bureaux has taken the initiative, in response to a large number of requests, of calling together representatives and individuals known to be interested in the formation of a permanent means of collecting, and making available to students and others, documentary and artistic material in the form of recorded sound. A meeting was therefore held on March 3 to discuss the matter, and to ascertain what is practicable now and in the near future.

Mr. Frank Howes (president of the Royal Musical Association), as chairman, gave an outline of the proposals already put forward in general terms, and the usefulness of such a potential organisation, started perhaps on the lines of the British Film Institute, was detailed by representatives of such important bodies as the British Museum, the British Council, the British Broadcasting Corporation (which uses sound recording on an immense scale in many forms), the National Register of Archives, the Scientific Film Association, the English Song and Folk Dance Society, the International Folk Music Council, departments of the University of London interested in languages, the commercial and private recording companies, the professional societies, and other individuals.

Mr. A. P. H. Saul described how collections of recorded material have been built up elsewhere, both on the Continent, especially Vienna, over the past fifty years, in Berlin and in the United States; but facilities are totally lacking in Great Britain. As a consequence valuable historical material is being lost, or at the best dispersed in private collections, of which no information is readily available. The interpretations of musicians, the voices of statesmen and poets, the remoter languages, the interesting cases of defective speech, and strange music of other lands are probably all available somewhere, but are denied to serious students of history, anthropology and phonetics.

Since practice is often better than mere precept, the value of such records was demonstrated most effectively by Mr. H. L. Fletcher, who played montage records, with comments, made that morning, from material received from a number of sources. Thus were reproduced the voices of Lloyd George, Asquith, James Joyce, Woodrow Wilson, Vesta Tilly (all pre-1914), Japanese music, an original 1660 pipe organ, a man of eighty recalling the original tune of "Brigg Fair", and modern poets. Also the voices of Gladstone, and, of course, all singers since 1900 are known to be available.

Questions of the copyright in reproductions for practical use, storage, finance, interchange with other countries, research and relations with other interested bodies were generally discussed. The meeting constituted itself a provisional council, having approved the idea that such an institute should go forward, and appointed a committee to study details and make a report.

With Mr. F. Howes as chairman the following were appointed to this exploratory committee: Mr. P. May (A.S.L.I.B.), Mr. A. P. H. Saul, Dr. D. B. Fry (Phonetics Department, University College, London), Mrs. J. Lancaster-Jones (British Council), Mr. D. Shawe-Taylor, Mr. A. C. Cameron (Educational Department, Electric and Musical Industries, Ltd.), Mr. H. L. Fletcher (Association of Professional Recording Studios) and Dr. L. E. C. Hughes (British Sound Recording Association).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Tuesday, March 30

MANCHESTER GEOGRAPHICAL SOCIETY (in the Geographical Hall, St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. H. E. Faulkner: "The East India Company".

SOCIETY OF INSTRUMENT TECHNOLOGY (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Mr. S. S. Carlisle and Mr. B. O. Smith: "An Experimental Electrical Pressure Meter for Measurement of Furnace Roof Differential Pressures".

ROYAL PHOTOGRAPHIC SOCIETY, SCIENTIFIC AND TECHNICAL GROUP (at 16 Prince's Gate, London, S.W.7), at 7 p.m.—Symposium on "Modern Techniques in Stereoscopy and their Applications".

Wednesday, March 31

MANCHESTER LITERARY and PHILOSOPHICAL SOCIETY, SOCIAL PHILOSOPHY SECTION (in the Portico Library, 57 Mosley Street, Manchester), at 5.30 p.m.—Mr. N. S. Hubbard: "The Place of Philosophy in Christian Civilization".*

BRITISH INSTITUTION OF RADIO ENGINEERS, MERSEYSIDE SECTION (at the Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool), at 6.45 p.m.—Mr. J. B. Birks: "The Physical Applications of Micro-Waves".

Thursday, April 1

MINERALOGICAL SOCIETY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. R. J. Halsey and Dr. J. H. Swaffield: "Analysis-Synthesis Telephony with Special Reference to the Vocoder".

INSTITUTION OF CIVIL ENGINEERS, NORTH-WESTERN ASSOCIATION (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Mr. F. D. C. Henry: "The Development of Motorway Projects".

ROYAL STATISTICAL SOCIETY, SHEFFIELD GROUP OF THE INDUSTRIAL APPLICATIONS SECTION (in Room B1, Department of Mechanical Engineering, The University, St. George's Square, Sheffield), at 6.30 p.m.—Mr. G. Komlosy: "The Application of Statistical Quality Control to a Steel Strip Mill".

Thursday, April 1—Saturday, April 3

SCIENCE MASTERS' ASSOCIATION, SCOTTISH BRANCH (at the University, Glasgow).—First Annual General Meeting.

Friday, April 2

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, PHYSICAL METHODS GROUP (at Birmingham), at 2.30 p.m.—Visit to the Physics Department of the University, Bristol Road, Edgbaston; at 6.30 p.m. (in the English Theatre, Mason's College).—Papers on "The Determination of Radioactive and Stable Tracer Isotopes".

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department, Imperial College of Science, Imperial Institute Road, London, S.W.7) at 3.30 p.m.—Mr. C. G. Wynne: "Wide-aperture Mirror Lens Systems"; Mr. R. W. G. Hunt: Demonstrations.

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "High-Speed Recording of Optical and Electrical Transients" (to be opened by Mr. H. A. Prime).

ROYAL STATISTICAL SOCIETY, LONDON GROUP OF THE INDUSTRIAL APPLICATIONS SECTION (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Dr. H. O. Hartley: "Some Short Cuts in Statistical Calculations".

SOCIETY OF DYERS AND COLOURISTS, MANCHESTER SECTION (at the Engineers' Club, Albert Square, Manchester), at 6 p.m.—Annual General Meeting.

Friday, April 2—Saturday, April 3

ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX, NORTHERN BRANCH (at Leeds).—Conference.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN BACTERIOLOGY at the Essex Institute of Agriculture, Writtle, Chelmsford—The Chief Education Officer, County Offices, Chelmsford (April 3).

LECTURER IN MATHEMATICS—The Principal, County Mining and Technical School, Nuneaton (April 3).

HEAD OF THE CHEMISTRY DEPARTMENT, and HEAD OF THE MECHANICAL ENGINEERING DEPARTMENT, in the Technical Education Branch of the Department of Public Instruction, New South Wales—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (April 5).

TEACHER OF BOTANY AND BACTERIOLOGY IN THE CHEMISTRY DEPARTMENT—The Principal, College of Technology, Belfast (April 5).

DISTRICT METALLURGIST, Mines Department, Southern Rhodesia—The Secretary, Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (April 7).

CHIEF LABORATORY TECHNICIAN FOR PATHOLOGY AND BACTERIOLOGY DEPARTMENT—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire (April 10).

SCIENTIFIC ASSISTANT IN THE DEPARTMENT OF THE CHIEF DEVELOPMENT AND RESEARCH OFFICER—The Staff Officer (Ref. ER/E.467), London Transport, 55 Broadway, London, S.W.1 (April 10).

SECRETARY TO THE INSTITUTE—The Registrar, University College Institute of Education, Hull (April 10).

SENIOR INDUSTRIAL CHEMIST and a JUNIOR INDUSTRIAL CHEMIST at the Atomic Energy Research Establishment, Harwell (for control of water supply to the Establishment, effluent disposal arrangements and general chemical service to the Chief Engineer, including control of boiler house, fuel economy, water treatment and large water distillation plants)—The Ministry of Labour and National Service, Technical and Scientific Register, Room 669, York House, Kingsway, London, W.C.2, quoting F.215/48A (April 12).

RESEARCH AND TEST BAKER to the British Baking Industries' Research Association—The Ministry of Labour and National Service, Technical and Scientific Register, Room 669, York House, Kingsway, London, W.C.2, quoting F.179/48 (April 12).

LECTURER (GRADE II) IN BOTANY (Morphological)—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 15).

LECTURER IN CHEMISTRY in the United College, St. Andrews—The Secretary, The University, St. Andrews (April 15).

SENIOR LECTURER IN PHYSICS and a LECTURER IN PHYSICS—The Principal, Chelsea Polytechnic, London, S.W.3 (April 15).

LECTURER (Grade IIB) IN THE DEPARTMENT OF GEOGRAPHY—The Clerk, Birkbeck College, London, E.C.4 (April 17).

LECTURER IN THEORETICAL PHYSICS and an ASSISTANT LECTURER IN THEORETICAL PHYSICS—The Registrar, The University, Manchester 13 (April 17).

SUPERINTENDENT OF THE PHYSICS DIVISION of the National Physical Laboratory in the Department of Scientific and Industrial Research—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2140 (April 21).

PRINCIPAL SCIENTIFIC OFFICER IN THE ARMAMENT RESEARCH DEPARTMENT of the Ministry of Supply—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2139 (April 22).

SENIOR PRINCIPAL SCIENTIFIC OFFICER IN THE INFESTATION CONTROL DIVISION of the Ministry of Agriculture and Fisheries—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2138 (April 23).

ENTOMOLOGIST in the Inter-territorial Tsetse Reclamation Department, East Africa—The Under-Secretary of State, Colonial Office (Research Department), Palace Chambers, Bridge Street, London, S.W.1 (April 24).

LECTURER (Grade II) IN THE DEPARTMENT OF PSYCHOLOGY—The Registrar, The University, Liverpool (April 24).

LECTURER IN SOCIAL ANTHROPOLOGY and a LECTURER IN PUBLIC ADMINISTRATION, for the Department of Social Studies—The Registrar, University, Leeds 2 (April 24).

PROFESSOR OF MATHEMATICS—The Secretary and Registrar, University College of North Wales, Bangor (April 24).

GOVERNMENT CHEMIST in the Public Works Department of the Gold Coast—The Director of Recruitment (Colonial Service), 15 Victoria Street, London, S.W.1 (April 30).

RESEARCH FELLOWS IN PHYSICS AND CHEMISTRY, including physical and organic chemistry, biochemistry, chemotherapy, pharmacology and engineering (Fellowships for Scientific Research established by I.C.I., Ltd.)—The Secretary, The University, Edinburgh (April 30).

LECTURER IN MATHEMATICS, to teach Pure and Applied Mathematics, more particularly the latter—The Very Reverend the Dean of Christ Church, Oxford (May 1).

LECTURER IN SOCIAL ANTHROPOLOGY, and a RESEARCH ASSISTANT IN SOCIAL ANTHROPOLOGY—The Secretary, University College, Gower Street, London, W.C.1 (May 1).

LECTURER IN VERTEBRATE ZOOLOGY and a DEMONSTRATOR, for the Department of Zoology and Applied Entomology—The Secretary, Imperial College of Science and Technology, South Kensington, London, S.W.7 (May 15).

LECTURER (Grade II) IN MARINE ZOOLOGY (Fisheries) at Port Erin Station—The Registrar, The University, Liverpool (June 9).

ADMINISTRATIVE OFFICER TO THE PNEUMOKONIOSIS RESEARCH UNIT of the Medical Research Council at Cardiff—The Director, Pneumokoniosis Research Unit, Llandough Hospital, Cardiff.

AGRICULTURAL CHEMIST IN THE DEPARTMENT OF AGRICULTURE, British Guiana, to undertake analytical and advisory work relating to soil crops and animal nutrition—The Director of Recruitment (Colonial Service), Colonial Office, 15 Victoria Street, London, S.W.1.

ASSISTANT EXPERIMENTAL OFFICER (male or female) IN THE PLANT AND ANIMAL PRODUCTS DEPARTMENT of the Imperial Institute, in the Intelligence Section—The Establishment Officer, Imperial Institute, London, S.W.7.

LECTURER IN PHYSICS—The Registrar, University College, Exeter.

MICRO-ANALYST IN THE DEPARTMENT OF ORGANIC CHEMISTRY—Prof. W. Baker, The University, Bristol 8.

SENIOR GEOLOGIST FOR THE MINES DEPARTMENT, Adelaide, to take charge and supervise geological investigations of the coal resources of the State and to advise on geological aspects of exploitation—The Agent-General for South Australia, South Australia House, Marble Arch, London, W.1.

TIMBER MARKETING OFFICER by the Government of Nigeria—Commerce and Industries Department—Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M/N/17860/3E.

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